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California Energy Commission

FOUNDRY ENERGY USE STUDY

Volume I - Engineering Study

1981

CALIFORNIA CAST METALS ASSOCIATION

1011 St. Andrews Drive, Suite I El Dorado Hills, CA 95762 (916) 933-3062

SECTION I

VOLUME I

ENERGY CONSERVATION IN CALIFORNIA FOUNDRIES

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SCOPE

The purpose of this energy conservation study is to define and analyze the high energy-consuming processes in various types of foundries located throughout California.

The study entitled "Energy Conservation in the Cast Metals Industry of California" will be presented in two separate volumes, namely:

- Volume I: Energy Conservation in California Foundries
- Volume II: Energy Management Workbook

Volume I will be broken down into three subsections as follows:

- Section I: Discussion of what can be done to conserve energy and/or reduce energy costs.
- Section II: How to set up an in-house energy audit and evaluation of results.
- Section III: Energy analysis of nine selected foundries.

Volume II will contain all necessary tables, charts, and graphs for use by the CAST METALS INDUSTRY in conducting an in-house energy audit, and by utilization of the mathematical models developed in Volume I - Section II, establish energy- and cost-saving procedures together with "return on investment" analysis for high capital cost changes. Identification of energy savings presented in this study will be addressed on a capital cost priority basis and will be itemized as:

- No Cost
- Low Cost (maximum $5,000 capital investment)
- Medium Cost (maximum $25,000 capital investment)
- High Cost (over $25,000 capital investment)

Applicable foundry operations analyzed in this study relate to:

A. Ferrous Foundries

1. Steel - carbon and alloy
2. Iron - gray, ductile and alloy
3. Malleable iron

B. Nonferrous Foundries

1. Aluminum

2. Copper base alloy

To protect the identity of the nine foundries selected for the energy management analysis, the following code will be utilized:

- Foundry "A": Malleable iron foundry located in Northern California and producing 1,530 net good tons of castings/year.
- Foundry "B": Gray iron and ductile iron foundry located in Northern California and producing 6,407 net good tons of castings/year.
- Foundry "C": Ductile iron foundry located in northern California and producing 2,520 net good tons of castings/year.
- Foundry "D": An investment casting facility located in Northern California and producing 500 net good tons of castings/year.
- Foundry "E": Steel foundry located in Southern California and producing 3,578 net good tons of castings/year.
- Foundry "F": Manufacturer of steel alloy ingot located in Southern California and producing 9,600 net good tons of ingot/year.
- Foundry "G": Aluminum foundry located in Southern California and producing 133 net good tons of castings/year.
- Foundry "H": Brass foundry, located in Southern California and producing 87 net good tons of castings/year.
- Foundry "I": Brass foundry, located in Southern California and producing 780 net good tons of castings/year.

INTRODUCTION

Foundries participating in the AFS - CMF energy reporting program continue to show progress in reducing the amount of energy required to produce a ton of net good castings. Increased energy cost and the availability of fossil fuels have provided an incentive to curb waste and to utilize purchased energy wisely. Energy costs now approach and sometimes exceed 6% of the sales dollar in the majority of foundries. Proposed cost increases for natural gas and electrical energy strongly indicates that energy costs may soon approach 10% of the sales dollar. According to the American Foundry Society, energy usage reports submitted by participating foundries show that the rate of energy use reduction is slowly decreasing. The following chart illustrates this trend.1/

RATE OF ENERGY USAGE

	1972	1973	1974	1975	1976	1977	1978	1979
Steel	26.69	25.05	23.89	22.73	22.44	21.36	20.37	19.47
Gray, Ductile & Alloy	12.35	11.71	12.04	11.80	11.58	10.72	10.90	10.58
Malleable	19.58	18.05	17.89	19.96	19.95	21.70	23.11	22.16
Aluminum	48.61	39.87	50.96	36.78	21.88	35.68	29.14	30.73
Copper	24.00	27.32	25.67	16.71	20.20	20.73	26.79	16.55

NOTE: Above figures are 10^6Btu's/net good ton

Even though the 1979 figures show a marked reduction in energy requirements in producing a ton of finished castings (with the exception of the malleable iron foundries) over the 1972 data base, the foundry industry must find additional areas where energy can be conserved - this is imperative in the coming years as our proven energy resources dwindle and costs skyrocket.

The average foundry consumes approximately 70 to 80% of its total energy input in three principal areas of operation:

- Melting operations
- Heat treat operations
- Ladle heating operations

1/Extraction from Modern Castings June 1980.

Areas of secondary importance for energy reduction measures are:

- Cleaning and finishing operations
- Mold and core making
- Pouring and shake-out
- Sand reclaim system
- Dust and fume collection
- Compressed air systems
- Heating, ventilation and air conditioning systems
- Process cooling water systems
- Domestic hot water heating systems

Additional areas where energy conservation measures may be utilized:

- Building lighting systems
- Building weatherproofing
- System shut down during nonproduction periods
- Improvement in preventive maintenance programs

Long term process changes for significant energy reduction measures are:

- Scrap preheating
- Increasing yield
- Reduction in casting weight
- Reduction in holding furnace operation
- Preheating of castings
- Cogeneration systems

As stated above, approximately 70 to 80% of a foundry's energy input is consumed by melting, heat treat and ladle heating operations. Investment casting facilities and foundries in colder climates of California, however, would reduce this percentage due to the relatively large amounts of energy consumed for large process air conditioning systems and make-up air ventilation systems.

The following is a typical example of the energy mix and annual consumption rates in a steel foundry located in California:

Item	Btu's per yr (x 10^6)	% overall energy	
Natural Gas			
Heat treat	30,180	42	41.8
Ladle heating	16,490	23	22.9
Core drying and misc. gas	681	1	
Subtotal	47,351		
Electricity			
Arc furnace (5 tons)	13,000	18	18.0
Induction furnace (250 kW)	1,000	1.5	1.4
Lighting	750	1.0	1.0
Major motors	7,000	10	9.7
Misc. Electrical	3,000	3.5	4.
Subtotal	24,750	100	
Foundry total	72,101		

NOTE: Above figures not applicable to nonferrous operations.

The above figures are purely hypothetical from the standpoint of yearly energy consumed by various processes; the overall energy utilization percentages are fairly representative of a steel foundry operation. The energy mix is approximately 66% gas and 34% electricity.

Based on the above observations this energy conservation study will address the three primary energy consuming processes, as previously mentioned, namely, metal melting, heat treating and ladle preheating. An in-depth energy management analysis will be performed, by utilizing hypothetical mathematical models, to illustrate the potential energy savings and energy cost reduction measures possible by modification of existing equipment and/or changing basic process operations.

The principal areas for the "in depth" analysis will be as follows:

A. Gas Consuming Equipment

1. Heat treat furnaces:

(a) Installation of recuperators to preheat combustion air.

(b) Changing of burner system from atmospheric type to sealed - pressure regulated burners.

(c) Upgrading of heat treat furnaces to eliminate cracks and openings.

(d) Change conventional fire brick to ceramic fiber liners.

2. Crucible or reverberatory furnaces:

   (a) Installation of recuperators to preheat combustion air.

   (b) Change burner system.

   (c) Replace castable refractory with vacuum - formed ceramic fiber.

   (d) Provide charge access covers while furnace is in a holding mode.

   (e) Install electric melt furnaces.

3. Ladle heating:

   (a) Change burner from atmospheric to gas and compressed air with regulators.

   (b) Install insulated covers

   (c) Add insulation

   (d) Change to electric ladle heating

B. Coke Consuming Equipment (Cupola)

1. Twin blast lined cupola

2. Hot blast lined cupola with recuperation

3. Hot blast water cooled cupola with recuperation and gas afterburners

4. Oxygen enriched cupolas

C. Electrical Consuming Equipment

1. Electric Arc Melting Furnace

   (a) Off-peak melting

   (b) Controlling demand

   (c) Maximizing heat transfer

   (d) Load management and optimization

   (e) Installing water cooled blocks

2. Induction Furnace Melting (Coreless)

   (a) Off-peak melting

   (b) Improve operational methods

   (c) Improved furnace design

   (d) Oxygen-fuel assisted melting

   (e) Water cooling heat recovery

   (f) Maximization of melting capacity

3. Induction Furnace Melting (Channel)

   (a) Off-peak melting

   (b) Improve furnace design

   (c) Water cooling heat recovery

Energy conservation associated with other foundry processes (i.e., those that collectively represent approximately 20% of total energy input) will be discussed briefly; no attempt will be made to quantify possible energy savings.

PERFORMING AN "IN-HOUSE" ENERGY AUDIT

An efficient energy management program can only be implemented successfully if energy consumption habits of various foundry equipment is identified and recorded in a logical and workable format.

The results of active energy management is improved energy utilization; this invariably pays off in dollars, as well as making a major contribution to the national drive towards energy conservation.

To effect this result management should implement the following procedures:

1. Understand the plant's energy services and organize for day-to-day control.

2. Cost the energy services to determine incentives for potential profit.

3. Apply the same basic business principles to energy services that are used for other materials and supplies.

4. Encourage a long range energy plan that fits future plans of the foundry.

5. Initiate regular performance reports on energy usage.

Before the above work assignments can be put into effect, a comprehensive plant energy audit must be conducted. The following is a step by step procedure for an "in-house" audit.

1. Analyze gas, electricity and miscellaneous fuel bills for the past 12 months and convert all energy information into Btu's; use the following conversion figures to accomplish this:

   - 1 kWh = 3,412 Btu's
   - 1 MCF natural gas = 1,000,000 Btu's
   - 1 pound coke = 12,500 Btu's
   - 1 gallon of propane = 91,600 Btu's

   While tabulating annual consumption of energy sources into Btu's and dollars, an attempt should be made to determine which departments use how many Btu's of which fuel type (installation of in-house metering is essential for accurate data - See Section I, Part B, page B-4 for further information).

2. Analyze and record production schedules for the same time frame used for energy consumption. Total number of units in pounds produced by each department and the entire foundry should be recorded, also on a month to month basis. Make sure all information is recorded in units <u>or</u> weight and not a combination of both.

3. Physically inspect all equipment and identify systems or processes which are wasting energy and offer the best cost effective energy program. To determine equipment efficiencies, the following data should be recorded:

   (a) Total running time of equipment per day

   (b) Hourly energy consumption converted to Btu's

   (c) Operating temperatures

   (d) Flue and stack temperatures

   (e) Flue and stack airflow rates

   (f) Combustion data: IE; CO_2 content of flue gas

   (g) Type and model number of gas burners

   (h) Ancillary motor horsepowers

   (i) Material through-put in pounds

   (j) Electrical demand profile and power factors

4. Utilization of data gathered under items 1, 2, and 3 will be sufficient to calculate;

   - Available heat to do useful work
   - Efficiency of equipment
   - Available heat for reclaimation
   - Electric power utilization and efficiency
   - Percent energy savings

Section II will show examples of how to construct an energy flow diagram by utilization of mathematical models. Also, Section II will illustrate the necessary procedures required to calculate potential energy savings.

Construction of energy flow diagrams for various equipment processes will identify which areas offer the greatest energy saving potential. The final step is to make an economic evaluation in order to calculate the return on investment for capital improvements. Return on investment (ROI) will require the following input information.

- First Cost (Capital Expenditure).....FC
- Annual Operating Costs..............AOC
- Annual Fuel Savings..................AFS
- Projected Fuel Price................PFP
- Estimated Life Time in Years.........EL

A simple method for economic analysis is to calculate the payback period; this method utilizes the above basic data and will be used in this study.

PART A

ELECTRICAL POWER

USE IN FOUNDRIES

As stated previously the typical usage of electrical energy in a steel foundry amounts to approximately 34% of the total energy used. The percentage could be much higher in foundries engaged in around the clock electric melting and minimal heat treat operations. Nonferrous foundries, on the other hand, will utilize less than 34% of electrical energy due to heavy gas melting.

Electrical energy is used in the following foundry operations:

- Melting metal
- Holding melted metal
- Transporting melted metal
- Transporting sand
- Transporting cores and molds
- Cleaning and finishing
- Environmental control
- Miscellaneous equipment
- Lighting

ELECTRICAL TERMINOLOGY

In this section reference will be made to various electrical units; to enable an understanding of each unit, the following identification is provided:

Pressure-Volt; The volt, the pressure or potential difference required to produce one ampere in a resistance of one ohm. 1 kilo-volt (kv) = 1,000 volts.

Quantity-Coulomb; The quantity of electricity conveyed by one ampere flowing for one second. Ampere hour, one ampere for one hour.

Power-Watt;	The watt is the power flow with a steady current of one ampere at a pressure of one volt. The kilowatt (kw) = 1,000 watts. One horsepower = 746 watts.
Energy-Joule;	The joule is the energy conveyed by one watt during one second, the kilowatt hour (kwh) is one kilowatt flowing for one hour.
Capacitance-Farad;	The farad is the electrostatic capacitance which will hold a charge at a pressure of one volt.
Current-Ampere;	The ampere, the rate of flow of a unvarying electric current.
Volt-Ampere;	The product of the rated load amperes and the rated range of regulation in kilovolts (kva).

READING THE BILL

The cost of purchasing electrical power from the utility companies is derived from four major factors; they are, energy charge, fuel-adjustment charge, demand charge, and low power factor penalty.

Other incidental items which affect the power charges are, character of service, service voltage, and equipment charges - these are fixed charges.

ELECTRIC BILL TERMINOLOGY

Example of a Typical 1979 Bill

BILLING DEMAND: 3840 (6)

BILLING CONSTANTS: KWH (2A) 12000 KVARH (3A) 12000

KILOWATT-HOUR METER NO.

SERVICE FROM		SERVICE TO		READINGS FROM	READINGS TO	KWH
05	24 (7)	06	25	1352	1415	756,000 (2)

KILOTWATT-HOUR METER NO.

SERVICE FROM		SERVICE TO		READINGS FROM	READINGS TO	KWH
05	24 (7)	06	25	0941	0981	480,000 (3)

MAXIMUM DEMAND: 3840 (4)

TOTAL KWH 756,000 YEAR 1979 TOTAL KVARH 480,000

REACTIVE DEMAND: 2438 (5)

(9) INCL. STATE TAX @ 1 CENT/100 KWH

RATE SCHEDULE A-7 (1)

DEMAND CUSTOMER OR SERVICE CHARGE: 3,615.70 (8)

ENERGY CHARGE: (9) 29,010.33

(10) GROSS BILL: 32,626.03

VOLTAGE DISCOUNT:

SERVICE ADDRESS

POWER FACTOR ADJUSTMENT: (11) 706.77 CR.

(13) NET BILL: (12) 266.38 CR.

31,652.88

PREVIOUS BALANCE

DEPOSIT REFUND

AMOUNT DUE: 31,652.88 (14)

1 The utility rate schedule A-7 is the key to analyzing the electric bill. It is normally included as part of the contract.

2 The energy used expressed in kilowatt-hours (KWH) is determined by the difference of two monthly meter readings times the billing constant 2A.

The billing constants 2A and 3A are also described as "Meter Multipliers". They are determined by the product of the current and potential transformer ratios installed at the particular location.

3 The reactive power used, sometimes called "wattless power", expressed in reactive kilowatt ampere hours (KVARH) is determined from a separate reactive meter similar to the KWH meter 2 above.

This power is required to magnetize the steel cores of motors and transformers. It is not registered on the KWH meter.

4 The maximum demand in kilowatts for the current month is read from a separate register on the KWH meter. The value is the largest quantity of kilowatts consumed in the 30-minute intervals during the month.

5 The reactive demand in KVAR is calculated from the formula KVAR = KW (KVARH/KWH).

6 The billing demand is the average of the maximum demand for the past 11 months and the current month's demand. The minimum is half of the past 11-month value.

7 Date and time span of the current billing.

8 The service charge, as specified in the rate schedule, is based on the billing demand item 6 and the service charge, is also used as the minimum billing if the energy usage falls to a low value.

9 The electrical energy charge is based on the kilowatt hours used as shown in item 2 . Certain adjustments are made to the energy charge determined from the meter readings as follows:

a) Energy cost adjustment known as "ECAC" varies with the change in fuel cost to the utility.

b) Fuel balance factor usually is a credit.

c) Load management factor.

d) State tax as indicated on the monthly bill.

10 The gross bill is the summation of items 8 and 9 .

11 The voltage discount is available for services that are metered on the high voltage or primary side of the power company transformer. This discount is made to compensate for the utility transformer losses which are now included in item 2.

12 The power factor adjustment may be a penalty or a discount depending on the amount of reactive power, item 3, required by a plant. Power factor is defined as the ratio of the kW to KVA, sometimes stated as the ratio of "real power to the apparent power", this value is not read directly from the utility meters but must be calculated. A simpler method, using a hand calculator, is to solve as a right angle triangle where power factor (PF) = KW/KVA = KWH/RKVAH

$$RKVAH = (KWH)^2 + (RKVAH)^2$$

$$\text{This month's PF} = 756{,}000/\ (756{,}000)^2 + (480{,}000)^2 = 0.849$$

$$\%PF = 100(0.849) = 85.\ \%\ \text{Power Factor}$$

On this rate schedule a power factor over 70.7% provides a credit; below a penalty, however, other utilities may use a different break even point - 85% is used by many.

13 City tax where applicable.

14 Net bill is the summation of all of the above charges, adjustments, and credits.

THE ENERGY CHARGE

Energy charge is based on the number of kilowatt hours (kWh) used during the billing cycle. The total kilowatt hours are multiplied by the energy charge for total energy billing. The energy charges can vary with the type of service, voltage, and energy consumption. The typical energy rate schedules[1/] are as follows:

1. General service schedule which is applied to electrical load demand of up to 8,000 (kWh) kilowatt hours per month. Thus a non-demand charge schedule, the cost of energy and demand are one charge.

2. Rate schedule A-12 is applied to electrical load demand of 30 to 1,000 kilowatt (kW) of demand per month. This schedule has an energy charge, fuel-adjustment charge, demand charge, and low power factor penalty.

3. Rate schedule A-22 is applied to electrical load demands of 1,000 to 4,000 kilowatt (kW) of demand per month. This schedule has an energy charge, fuel-adjustment charge, demand charge, and low power factor penalty. This rate schedule has a "time of day" billing rate for energy and demand for both summer and winter. The summertime hour periods are from 1 May to 30 September; the energy and demand charges change between the following hours:

- Peak hours - 12:30 pm to 6:30 pm = 6 hours
- Partial peak hours - 8:30 am to 12:30 pm = 4 hours
- Partial peak hours - 6:30 pm to 10:30 pm = 4 hours
- Off peak hours - 10:30 pm to 8:30 am = 10 hours

The wintertime hour periods are from 1 October to 30 April; the energy and demand charges change between the following hours:

- On peak hours - 4:30 pm to 8:30 pm = 4 hours
- Partial peak hours - 8:30 am to 4:30 pm = 8 hours
- Partial peak hours - 8:30 pm to 10:30 pm = 2 hours
- Off peak hours - 10:30 pm to 8:30 am = 10 hours

[1/] Applicable to PG&E - Northern California only.

4. Rate schedule A-23 is applied to electrical load demands of 4,000 and above kilowatts (kW) of demand per month. All other charges and "time of day" billing hours and periods are the same as rate schedule A-22. Additional rates are available for the purchase of supply voltage of 4,500 or 12,000 volts, this schedule provides for a high voltage discount of the total energy and demand charges.

THE FUEL-ADJUSTMENT CHARGE

This charge is tied directly to the energy charge and can only be reduced by a reduction in overall energy usage. The fuel-adjustment charge permits the utility companies to adjust the total cost for producing energy due to increased fuel costs, without making a request for a rate increase.

THE DEMAND CHARGE

This charge compensates the utility company for the capital investment required to serve peak loads, even if that peak load is only used for a few hours per week or month. The demand is measured in kilowatts (kW) or kilovolt amperes (kVA); these units are directly related to the amount of energy consumed in a given time interval of the billing period. The demand periods vary with the type of energy demand; the high fluctuating demand has a short demand period which can be as short as five minutes, but generally demand periods are of 15 or 30 minutes. The period with the highest demand is the one used for billing demand charges. For instance, on a 15-minute demand period with a 70 kilowatt demand, and then adding a further 70 kilowatt demand for 15 minutes and then dropping back to 70 kilowatts for the rest of the billing period, the billing demand then is 140 kilowatts for that month. This represents the interval of maximum energy demand from the utility system for that month. Demand charges can be a significant portion of the total electrical bill; in some cases, demand charges can amount to as much as 80 percent of the bill. The demand charge can be reduced by smoothing out the peaks in energy demand by rescheduling of work or through a demand control program to shed loads when a demand limit is approached.

POWER FACTOR

Power factor, in simple terms, is the ratio of actual power used in a circuit, expressed in watts or kilowatts, to the power which is apparently being drawn from the line, expressed in volt-amperes or kilovolt amperes. Mathematically, power factor is expressed as

$$PF = \frac{KW}{KVA} \text{ or } KVA \times PF = KW$$

Power factor can also be defined as the factor to multiply apparent power in order to obtain active power. For example: Assume a load on a 480 volt 3-phase system, the ammeter indicates 200 amps and the wattmeter reads 120 KW - What is the power factor of the load?

The apparent power for a 3 phase circuit is given by the expression;

$$KVA = \frac{E \times I \times 1.73}{1000}$$

$$= \frac{480 \text{ volts} \times 200 \text{ amps} \times 1.73}{1000} = 290.6 \text{ KVA}$$

Therefore: $$PF = \frac{KW}{KVA} \text{ or } \frac{120}{290.6} = \underline{\underline{41.2\%}}$$

From the above example it is apparent that by decreasing the power drawn from the line (kVA) the power factor can be increased.

POWER FACTOR IMPROVEMENT

Preventive measures involve selecting high-power-factor equipment. Only high-power-factor ballasts should be used for fluorescent and high-intensity-discharge (HID) lighting. Power factor of so-called normal-power-factor ballasts is notoriously low, on the order of 40 to 55 percent.

When induction motors are being selected, the manufacturer's motor data should be investigated to determine the motor power factor at full load. In the past few years, some motor manufacturers have introduced premium lines of high-efficiency, high-power-factor motors. In some cases, the savings on power factor alone can justify the premium prices charged for such motors. Motors should also be sized to operate as closely as possible to full load, because power factor of an induction motor suffers severely at light loads. Power factor decreases because the inductive component of current that provides the magnetizing force, necessary for motor operation, remains virtually constant from no load to full load, but the in-phase current component that actually delivers work varies almost directly with motor loading.

Corrective measures for poor power factor involve canceling the lagging current component with current that leads the applied voltage. This cancellation can be done with power-factor-improvement capacitors, or by using synchronous motors. Capacitors have the effect of absorbing reactive current on a one-to-one basis, because almost all of the current flowing through a capacitor leads the applied voltage by 90 deg. A capacitor rated at 100 kilovolt-amperes capacitive (kvac) will, therefore, cancel 100 kilovolt-amperes reactive (kvar).

Synchronous motors provide an effective method of improving power factor because they can be operated at leading power factor. Moreover, power factor of a synchronous motor can be varied by varying the d-c excitation applied to the motor. To be effective in improving power factor remember, a synchronous motor cannot be applied to intermittent loads, because overall plant power factor will decrease when the motor is not in service.

A synchronous motor can be used in lieu of an induction motor, with a resulting improvement in power factor. In this example, using a synchronous motor to serve a load with actual power requirements of 1,000 kW, improves power factor on the load center from 80 percent to 89 percent. This improvement at the load center contributes to an improvement in overall plant power factor, thereby reducing the power factor penalty on the plant electric bill. The burden on the load center, plant distribution system, and entire electric-utility system is 400 kVA less than if an induction motor with a power factor of 85 percent were used. Power factor can be improved still more by operating the synchronous motor at leading power factor.

POWER DEMAND CONTROLS

The power demand controller automatically regulates or limits operation in order to prevent set maximum demands from being exceeded. The role of such a power demand controller has been widely recognized, the "time of day" billing rates will make it far more necessary in the future. The type of controller best suited to a foundry operation is that which will predetermine the demand limit and the demand interval.

The overall usage of power is constantly monitored from the power company meter, the power usage of all the controlled loads is also monitored. By having this information the controller can calculate when an overrun of the desired demand limit will occur. The controller will delay any shed action to allow time for loads to shed normally. When it is determined that it will be necessary to shed one or more loads, to keep from exceeding the demand, the controller at the last possible moment will shed the necessary loads. This means that shedding will occur only once during a demand interval and maximum use of available power will be realized.

DEMAND SHIFTING

Due to the lack of availability and the increased cost of natural gas and petroleum products, industry has come to rely on electrical power as an alternate source of energy. The use of electrical energy has increased at a greater rate than was anticipated and therefore a critical shortage has also been created. This is particularly true during the normal working day hours. Over the past few years this condition has caused situations known as "brown-outs", which is controlled curtailment of power.

Even with power companies doing their best to cope with the problem by building new generating stations, installing additional equipment in existing facilities, and operating all equipment at maximum capacity, they still have not been able to keep up with the rapid growth in the demand for electrical energy.

The demand for electrical energy is not constant, but occurs in peaks and valleys. Power companies are obligated to have enough equipment available to meet a customer's peak demand, even though this equipment is only used during the peak periods and is not in use during most of the working day. In order to finance the equipment necessary to provide this peak demand service for industrial users, the power demand charge was created.

In some localities this high demand rate is the rate which is paid for the next year, even if it is never reached again. The price paid for power demand is very high.

With the peaks and valleys in electrical demand, caused by electrical melting during the normal work day, maximum demand peaks should be controlled by sequencing the furnace's operation and maximum power input to each furnace. By applying this procedure, the revised operation would level out the peak demands and produce a flat demand profile during normal day time melting. With this melting operation the "Load Factor" would be improved, thus preventing high maximum demand peaks, which are developed through all furnace's operating on full power at the same time. (See Figures 1 and 2 for comparison.)

OFF-PEAK MELTING

With the revised billing methods of "time of day" rates being adopted by the electrical utility companies, any energy user of 1,000 kilowatts (kW) or over of demand, each month, will be billed on the "time of day" billing rate schedule. It will be noted from the schedule that demand and energy charges are high during normal working hours, with no demand charge during the night hours and very low energy charges. If the metal melting operation was moved to a night operation, maximum savings could be made on energy costs with no demand cost charge. The amount of night melting will depend on the total melting and holding capacity available.

If the melting and holding capacity is limited, it may require molding and pouring to be carried out at night together with melting to take full advantage of the "off-peak" electrical rates.

For graphic illustration of off-peak melting operations see Figure 3. For load profile for off-peak melting see Figure 4.

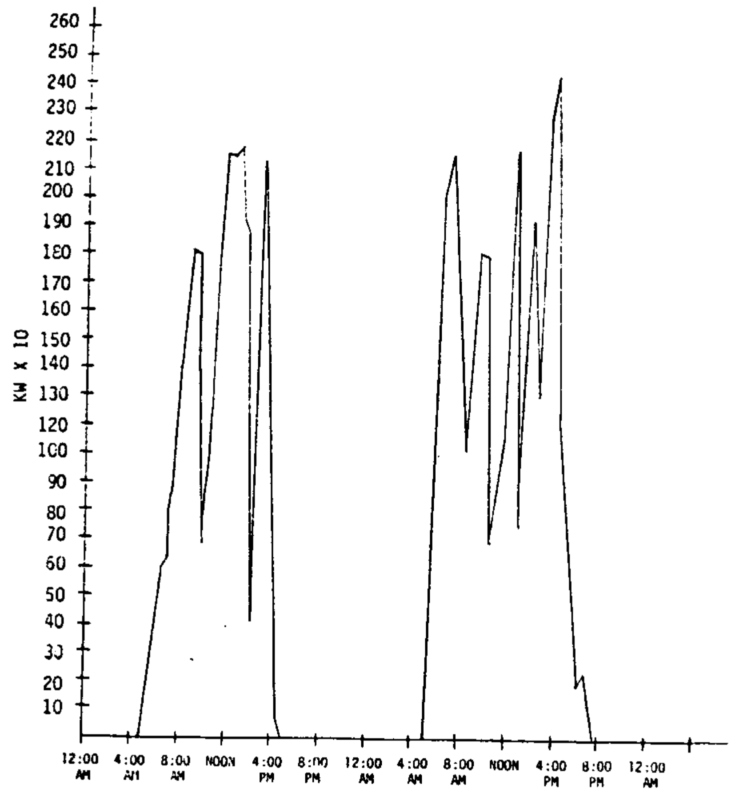
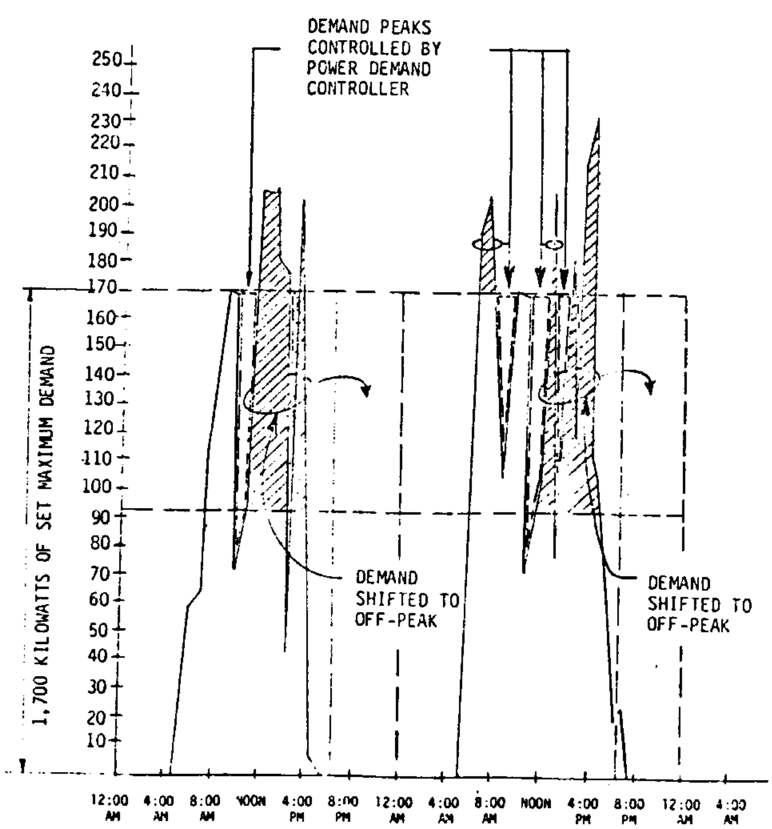


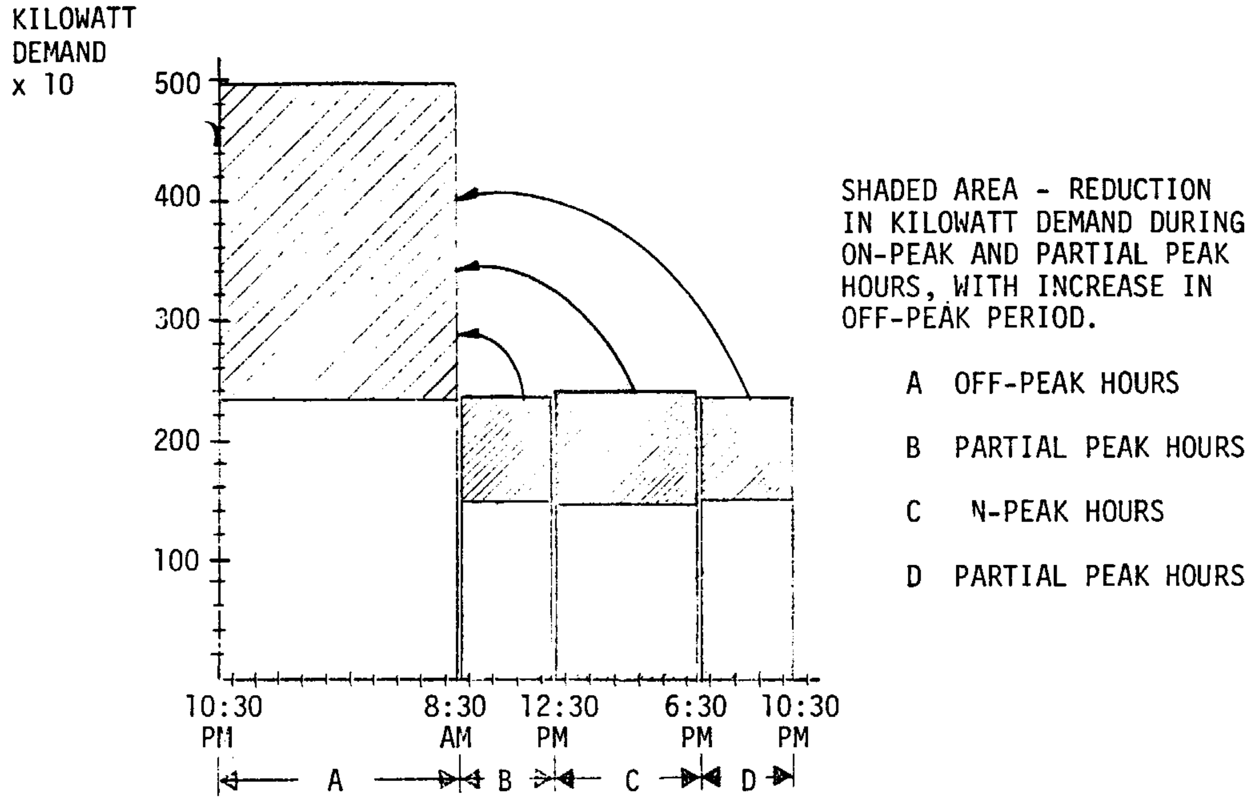
FIGURE 1.

SUMMER "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE (UNCONTROLLED)

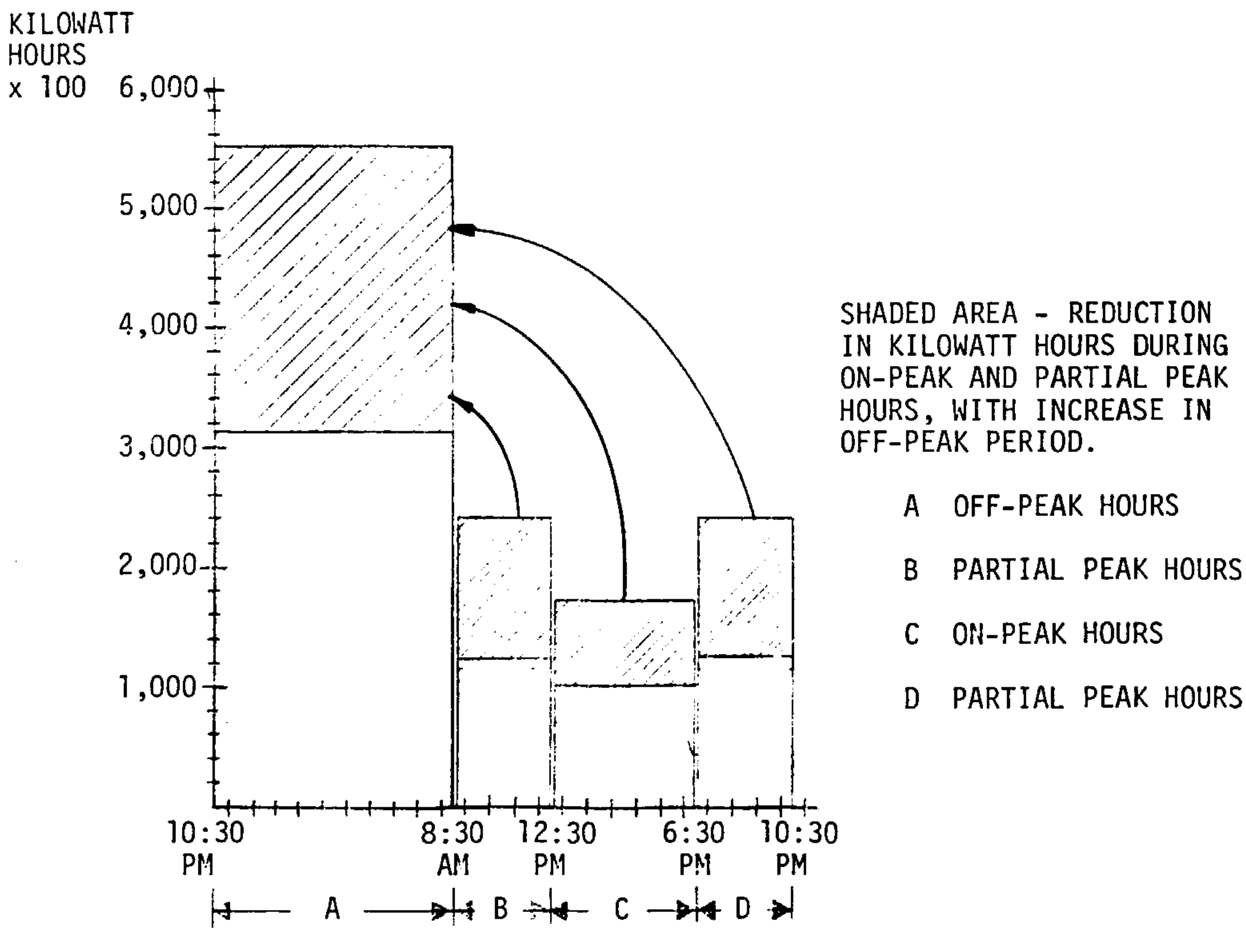
FIGURE 2.

SUMMER "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE (CONTROLLED)





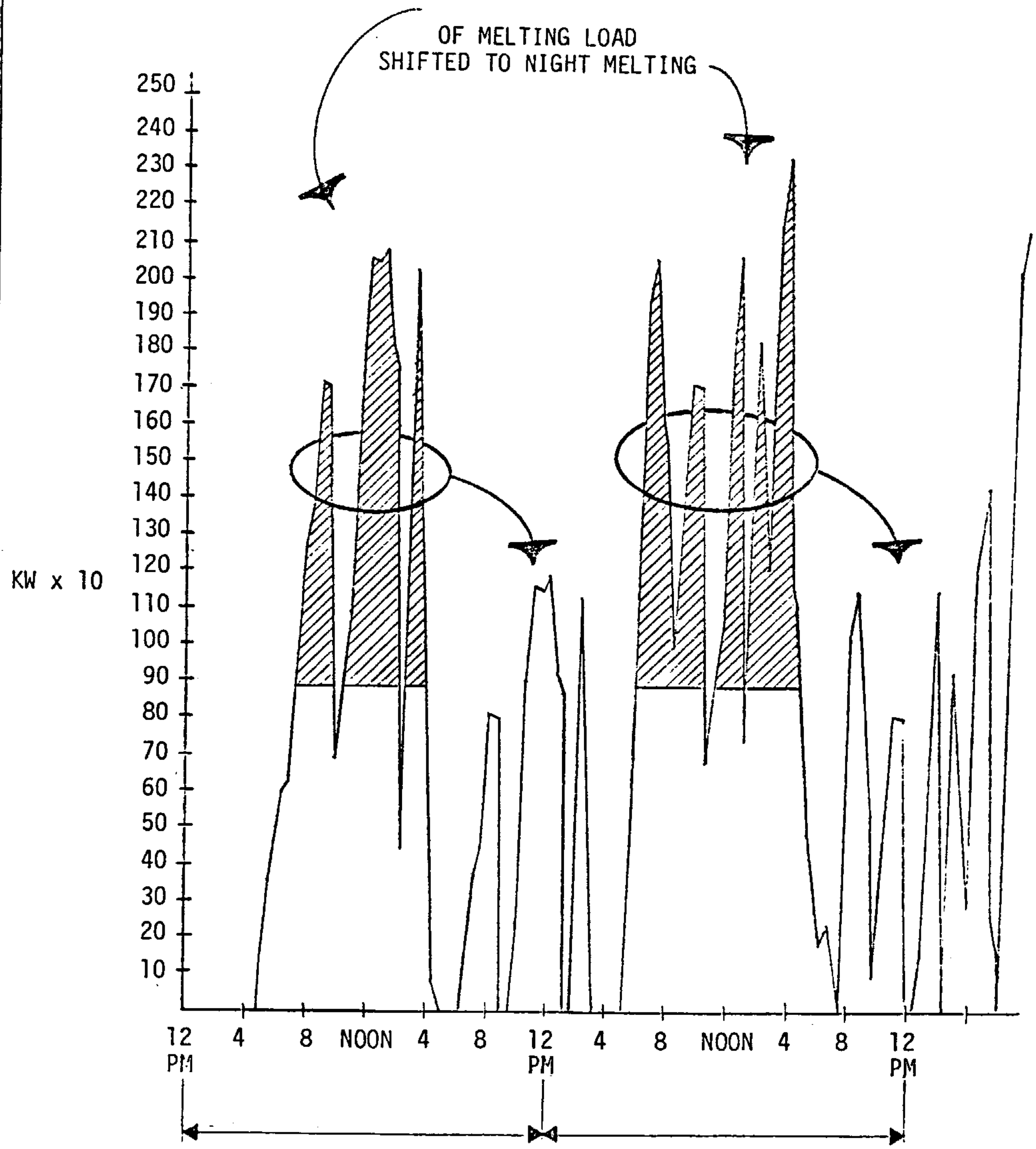
KILOWATT DEMAND BY "TIME OF DAY" BILLING



KILOWATT ENERGY USAGE BY "TIME OF DAY" BILLING

GRAPHIC ILLUSTRATION OF "OFF-PEAK" MELTING

FIGURE 3



LOAD PROFILE - "OFF-PEAK" MELTING

FIGURE 4

MAXIMIZATION OF MELTING CAPACITY

In this and other sections of this study, references and recommendations have been presented for electrical energy conservation in the melting of metal. As previously stated, approximately 34% of the total energy used in a typical steel foundry is electrical of the 34% approximately 20% is used for melting or holding melted metal. The total kilowatts used for melting a ton of metal can only be improved with furnace efficiency and operation, which will reduce the melt rate (tons/hour) and reduce energy consumption (kilowatt hours/ton). Areas whereby maximizing the melting capacity can save substantial energy are:

- Load factor should operate at high percent power utilization. The measure of the efficiency of utilization of electrical energy, taken on a monthly basis, is determined as the ratio of the average consumption in the month to the peak demand in that month.

- Electrical power costs per ton of metal melted will increase when "holding" metal for any length of time due to decreased power utilization. This condition is due to the thermal losses becoming proportionally larger when the furnace is in the idling mode, thus a melting coperation should utilize full furnace power whenever possible and restrict idling time, thereby maximizing energy-saving potential.

- During slagging and charging, it is necessary to open the lid to accomplish the intended actions. When the lid is open, thermal losses occur due to radiation from both the lid refractory and from the molten iron. The longer the lid-open time, the greater the loss of energy from the furnace. It follows that the energy consumption charge will increase with increase lid-open time, thus lid-open time should be no longer than absolutely necessary. By pouring the slag over the spout into the transfer ladle and then skimming the ladle before delivering metal to the pouring line will eliminate the radiation losses for slagging the furnace, thus saving significant energy. Some temperature is lost while slagging the ladle, but the furnace utilization rate is improved.

- The on-load solid-state stepless power control has the following advantages:

  1. Furnace power can be maintained at a maximum level throughout the lining campaign.

  2. Furnace power can be phased back exactly as required by the plant demand control system.

  3. Furnace power can be phased back easily while tapping and charging, which increases productivity.

• A good furnace operator can save energy in many ways. Fast charging and slagging of the furnace, with minimum cover "open time", will save the most heat energy. Getting metal at temperature shortly before it is dispatched to the molding line and not keeping the metal in the furnace at its highest temperature for a prolonged period of time will result in less heat losses via refractory and spout; an added advantage is prolonged lining life. With an automatic molding line operation, it would be practical to deliver to the pourer in constant intervals, and deliver only the amount of metal he can pour in the molds rather than supply him with a constant amount of metal he cannot pour off before it cools down to the point where pigging is required.

MELT FURNACE IMPROVEMENTS

Electric Arc Furnaces

The arc furnace is a refractory-lined vessel. At the beginning of the melting cycle it is filled by swinging aside the movable refractory roof and dumping in a charge of metallic scrap. The electrical energy needed to convert this charge to liquid metal is transmitted through several electrical distribution components, ending with the electrodes in the arc furnace (see Figure 5).

The furnace transformer takes the high transmission voltage and converts it into a lower operating voltage. The operator can choose from several operating voltage levels called "tap voltage".

Energy consumption, measured in kwh per ton, is fairly constant in most arc furnace operations, ranging from 450 to 550 kwh/ton of charge, depending on the scrap type and length of heat. There are few opportunities to decrease power comsumption in electric arc furnace melting because the roof is off only for charging. Other than recovering heat from cooling water or furnace stack little can be done to improve efficiency. Scrap preheating is an effective energy and electrode saver; for further details see part "F", Page F-1.

Energy cost savings however can be substantial by applying the following procedures:

- Off Peak Melting
- Demand Limiting
- Demand Shifting

Energy conservation in arc melting is closely tied to power distribution, power demand regulation, furnace regulation and, most important, operating practices.

In a given furnace, the fastest heat usually not only produces the most tonnage but also converts energy most efficiently. The heat transfer at the arc should be optimized under various operating conditions. Bore down and melt down are normally best performed using maximum power for long arcs whose increased mobility speeds up the conversion of scrap to hot metal with minimum electrical losses. During meltdown, where the arc is surrounded by scrap, aproximately 75 percent of all energy is used and thermal losses are at a minimum. During the refining period, when sidewalls are bare and only energy at a low power level is needed, to raise the bath temperature a few degreees, thermal losses are correspondingly higher.

Energy conservation in arc melting can be affected by many different variables. The most important ones are:

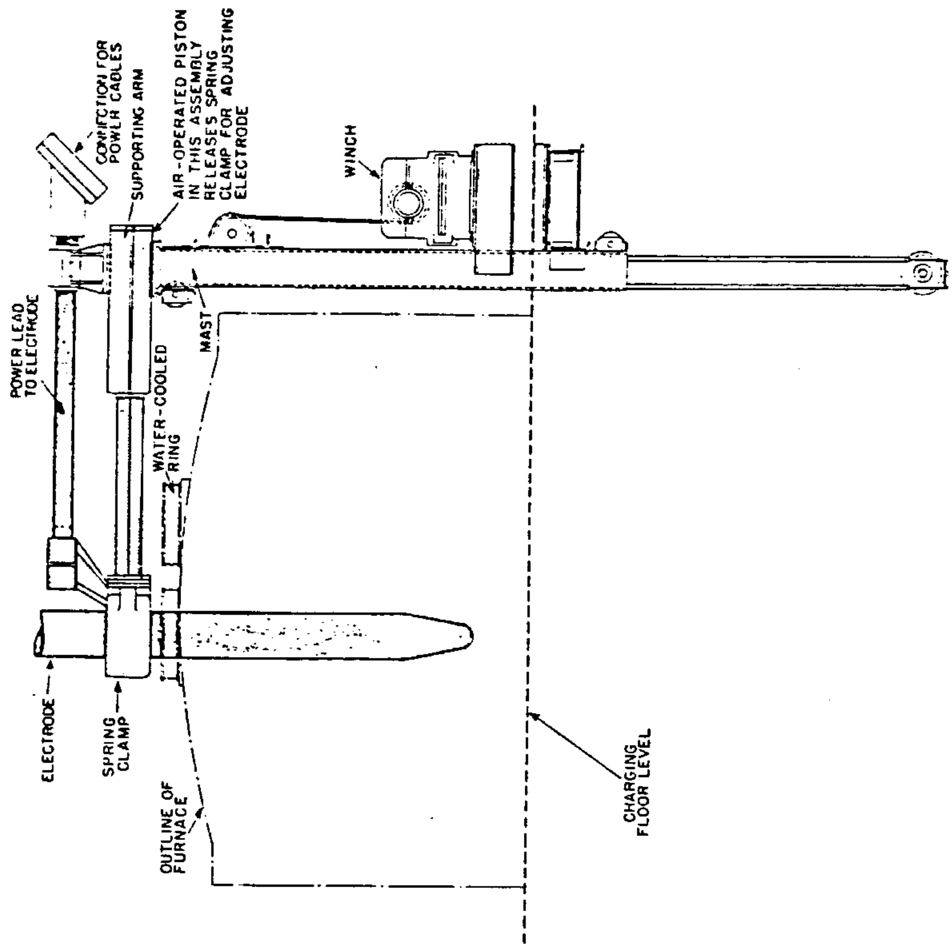
- arc furnace regulation -- This system automatically lowers and raises the electrodes during the automatic mode of operation, always responding to the change in secondary current and voltage, and maintaining a pre-set distance between the electrode tip and the furnace charge. A regulating system which is not optimized can result in long and inefficient heats, requiring additional energy.

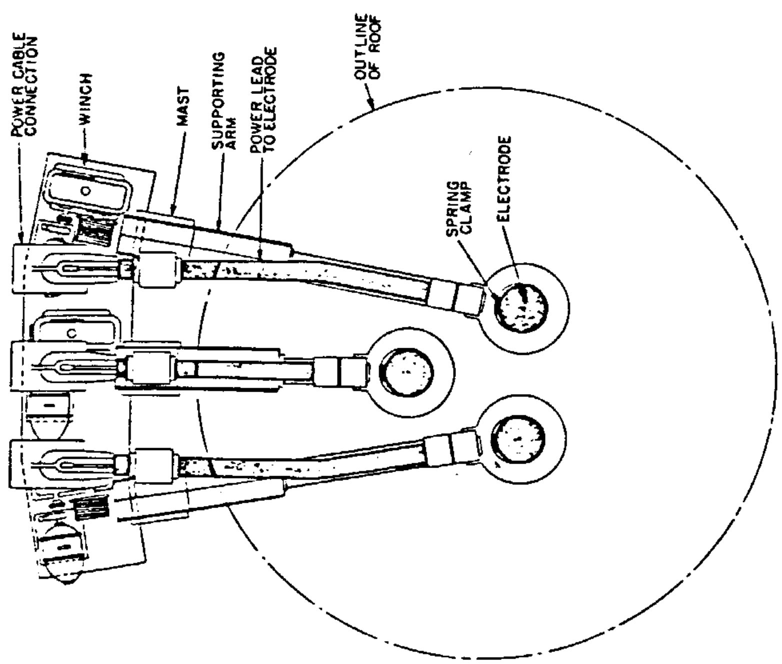
- power system characteristics -- Primary power distribution switching by the supply and power company can change the existing short-circuit capacity and perhaps the primary voltage which in turn affects the arc length, resulting in excessive electrode consumption or excessive refractory erosion. This type of variable will also affect furnace productivity resulting in a higher consumption of energy.

- operating delays -- Interruption in melting, scheduled or unscheduled, by unnecessarily lengthening the heat time, reduces furnace output and adds to the thermal losses in melting and can greatly increase the consumption of energy.

- human element -- People are responsible for most major problems or improvements in energy conservation. Unnecessarily long, inefficient heats caused by many different interruptions always require additional energy. Energy can also be wasted by not using optimum voltage selection or by inappropriate changing power input, power factor and current due to misuse of electrical control devices. More and more arc furnace melt shops are leaning toward eliminating the human element and expanding into automatic melting for better production and improved energy conservation.

A power profile or power program, which takes into consideration the full equipment capability, can be used with or without automated operation to greatly improve overall melting performance and energy management. This program defines precisely when to change the power input characteristic or when to recharge by noting the consumption of energy (kw/hr) in relation to weight and makeup of charge material.





SCHEMATIC ARRANGEMENT OF THE ELECTRODES, THEIR SUPPORTING MASTS, AND THE ELECTRICAL POWER LEADS FOR AN ELECTRIC-ARC STEELMAKING FURNACE

FIGURE 5

Induction Furnaces

Iron foundries that utilize electricity for melting use mostly coreless and channel type induction furnaces. All induction furnaces operate on the principle that when alternating current is passed through a coil, a magnetic field is created which induces eddy currents in a metal charge placed within that field. The degree of heating achieved is dependent on the rate of variation of the magnetic field (frequency) and on its intensity (power).

Channel furnaces are used for melting and duplexing, the requirements to always keep a heel in the furnace and the limitations of inductor power level limits their application as a primary melter. Electrical efficiency of an inductor is 94-95 percent, this is extremely high compared to coreless furnaces with a 76-81 percent efficiency.

Coreless furnaces reject approximately one fifth of the total energy consummed to the cooling water system, therefore considerable work has been done to improve furnace design.

The use of profile "D" (see Figure 6), for the power coil, reduces the magnetic flux lines penetrating through the outside corners which minimizes eddy current losses. Also, "D" profile allows the coil to be wound tighter with sufficient creepage distance which improves efficiency.

The cooling coils (Figure 7), on top and bottom, extract energy which should have gone into the melt, the use of castable backup refractory eliminates the need for cooling coils.

Electrical efficiency of the induction furnace can be increased as much as 10% with these improvements. A foundry producing 20 tons a day can save approximately $20,000 annually with 10% improvement in efficiency (cost of electricity 4¢ kwh including demand charge).

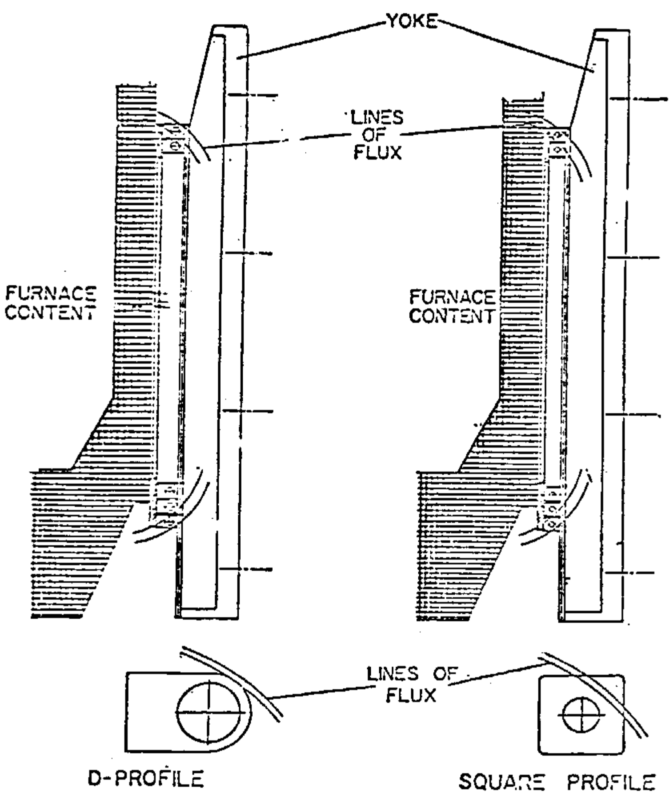


FIGURE 6

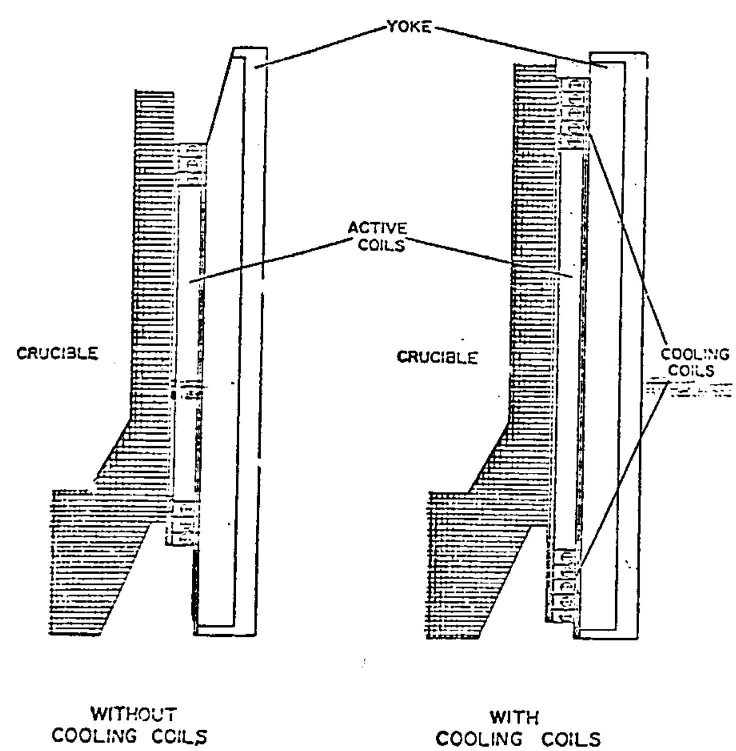


FIGURE 7

Electric Glo-Bar Reverberatory Melting Furnace

Much like the fuel-fired furnace, the Elecric Reverberatory Melting Furnace (ERMF) is constructed with an aluminum-resistant refractory lining and a structural steel shell. The total height of the furnace is much lower because the bath depth is more shallow, and less space is required above the bath. The furnace is heated by silicon carbide elements mounted horizontally above the bath. Heat is transferred through direct radiation from the elements and radiation from the refractory roof and sides.

The second type ERMF metal melting system employes electric immersion type elements. The elements are inserted into silicon carbide tubes which are immersed into the molten aluminum. Through radiation, the element passes its heat to the silicon carbide tube and through conduction, the tube releases its heat into the bath. With the heating length of the element six inches from the bottom of the bath, temperature uniformity is good. With this immersion type, heat does not have to be driven down through the bath from the surface.

Because the electric furnace does not need a flue, the heating chamber can be made almost airtight with the only heat loss being through the shell and from exposed radiant metal surfaces. A well is provided for charging of scrap and solids so there is no need to open the access door to the main chamber.

Metal Melting Loss

The metal loss from dross, due to the exclusion of oxygen, is one percent for 11,000 lbs. of aluminum metal. At the present metal cost of 70 to 77 cents per pound this represents a very significant loss, and potential for savings.

Metal Quality

With the melting of aluminum metal, low gas levels and minimum oxide inclusions are a must. The only source of hydrogen gas in an ERMF is from the materials being charged into the furnace. Treatment of scrap and clean ingots keeps hydrogen gas at low levels.

Working Conditions

Working conditions around an ERMF are vastly superior to gas-fired reverbatory furnaces, the two major differences being noise and heat. ERMF are practically noiseless, a bank of gas-fired reverbatory furnaces create noise levels close to OSHA limits of 90 decibels. The heat loss from a bank of gas-fired reverbatory furnaces is extremely high and could amount to approximately 15 times more than the ERMF.

Furnace Covers

Uncovered charging and dip-out wells and bath radiates 20,000 $Btu/ft^2/hr$ vs only 500 $Btu/ft^2/hr$ for a covered well, a factor of 40 times. The importance of well covers in a holding situation cannot be overemphasized.

Graphite Rod Holding Furnace

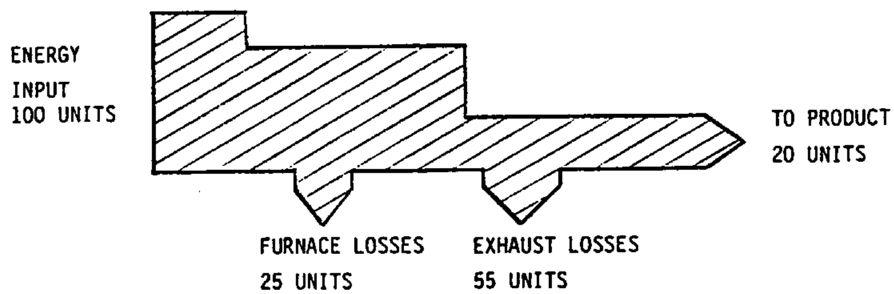
As the graphite rod holding furnace is not a primary melting furnace, this furnace will not be addressed with regards to cost savings. The efficiency and utilization of energy input to metal holding is high. The power factor is maintained at near unity. With this type of unit not much design improvement is possible.

PART B

NATURAL GAS AND EQUIVALENT FOSSIL FUELS

USAGE IN FOUNDRIES

As stated previously in this study, a typical steel foundry uses up to 66% of its fuel energy input for gas fired equipment. In most foundries overall efficiency of melt furnaces, heat treat furnaces, and ladle heating is about 20% or even lower which, in relative terms, means that for every 100 units of gas energy input only 20 units are utilized to heat the product, the remaining 80 units are expended in furnace losses and exhaust losses.



EXAMPLE: PROCESS ENERGY FLOW DIAGRAM

By drawing a process energy flow diagram, as illustrated above, one can actually see the major areas of concern. Once the above information has been developed, an energy flow diagram of the same process under ideal conditions can be developed. By comparing the actual diagram to the ideal, one can further improve chances of maximizing energy savings while minimizing capital investment.

Energy recovery is usually the first area addressed for energy maximization, a closer look at the problem will usually prove that improvements in the combustion air to gas ratio, furnace pressure controls, insulation, and refractory produce the bulk of the available energy savings at the least capital cost.

TERMINOLOGY AND THE BILL

Unlike electricity, gas utility bills are very simple to read, the following is a typical example of a monthly gas utility bill:

1

SERVICE PERIOD	
06-18-79	07-18-79

SERVICE ADDRESS: ____________

2

RATES	THERMS
GN-1	
GN-2	17,667
GN-3	22,486
TOTAL	40,153

$ 9,760.09

3

METER NUMBER	METER READINGS PREVIOUS	METER READINGS PRESENT	DIFFERENCE	BILLING FACTOR	THERMS
2345678	917920	955980	38060	1.055	40,153

BOX 1 is the service period on a monthly basis.

BOX 2 is the rate schedule and therms used.

Gas company rates are based on the following priority schedule:

- GN-1 is for residential and small industrial users consumming less than 100,000 cubic feet of gas per day.
- GN-2 is for industrial users consuming over 100,000 cubic feet per day.
- GN-3 is for industrial users consuming over 100,000 cubic feet per day and who have standby fuel capability.

Box 3 shows the actual months consumption in cubic feet of gas.

The billing factor is the actual heat content of the gas. (Can vary depending on location).

The final column is the amount of therms used for the month.

Our hypothetical bill is interpreted as follows:

1.	Gas consumption @ GN-2 rate	= 17,667 therms
2.	Gas consumption @ GN-3 rate	= 22,486 therms
3.	Total gas consumption	= 40,153 therms
4.	Difference in meter readings	= 38,060 cu ft
5.	BTU content of gas	= 1,055 BTU/cu ft
6.	Amount of therms used per month = $\frac{38,060 \times 1,055}{*\ 100,000}$	= 40,153 therms

* 1 therm = 100,000 BTU

Actual BTU's consummed = 4015.3×10^6 BTU

IN PLANT METERING

The monthly gas utility bills show how many Btu's have been expended to produce a product, what the bill does not tell you is where the Btu's were used in a particular gas consuming process.

Because of recent efforts towards the development of a comprehensive national energy program, the Foundry Industry can expect to pay even more for less available gas in future years. Foundries that will remain dependent upon gas for their production processes will be placing even greater emphasis on in-plant conservation efforts in order to achieve maximum production efficiency from this increasingly expensive fuel.

Cost allocations, within departments, and fuel surcharges to customers will become commonplace. Close monitoring of allocated supplies will become a necessity in energy management.

The basic and most important tool in energy management is an energy monitoring system. Before energy can be saved, an accurate metering system must be established in the foundry to determine exactly how and in what quantities, energy is being used, considerable savings can be realized almost immediately from the data derived from an energy audit using in-plant metering.

Proposed legislation for a users tax on natural gas for industrial purposes may very well make "in plant" metering an accounting prerequisite. Gas consumption monitoring can be used to control oven or furnace temperatures and prevent over-temperature damage, also equipment problems can be detected before they cause emergency shut down.

Measuring fuel consumption alerts maintenance crews to a variety of potential problems such as:

- Leaking fuel lines

- Faulty temperature measuring devices
- Faulty relief valves
- Excessive burner cycling
- Warped furnace doors
- Deteriorating furnace insulation

A relatively low cost monitoring device is the "Annubar". This device is a primary flow sensor designed to produce a differential pressure that is proportional to flow. The flo-tap Annubar can be inserted and removed from operation without system shut down - see Figure 1.

Annubar can be interfaced with secondary devices, a standard flow meter is available for rate of flow indication. It can be used as a portable meter or permanently mounted.

Annubar connected to a Differential pressure transmitter (Electric or Pneumatic) is used with a variety of standard secondary equipment for totalizing, recording or controlling complex systems - see Figure 2.

For description of Annubar operation see Figure 3.

OBTAINING A COMBUSTION ANALYSIS

In order to determine the operating efficiency of melt and heat treat furnaces it is imperative that a flue gas analysis be made. One of the best ways available for obtaining a flue gas analysis for CO_2 and O_2 is a FYRITE combustion analyzer.

In most actual combustion processes the determination of correct air-fuel ratio cannot be made by direct measurement of entering air, since various leakages through auxiliary openings will be responsible for a substantial increase in total air over that metering at the burner, thus for practical purposes the air-fuel ratio must be determined by calculation from data available, hence the combustion analyzer.

The flue gas data resulting from a FYRITE analysis are used with suitable charts (see Section II) for determining the percent excess air and, together with the information on flue gas temperatures, to determine the heat lost in the stack.

TYPICAL SET-UP DIAGRAM

TO UPDATE YOUR MEASUREMENT OR CONTROL SYSTEM

Installation of sensor in existing lines - Sensor can be installed in any portion of system,even underground without need for a permanent access pit,in less than 3 manhours with standard procedurs requiring no system shutdown, see below.

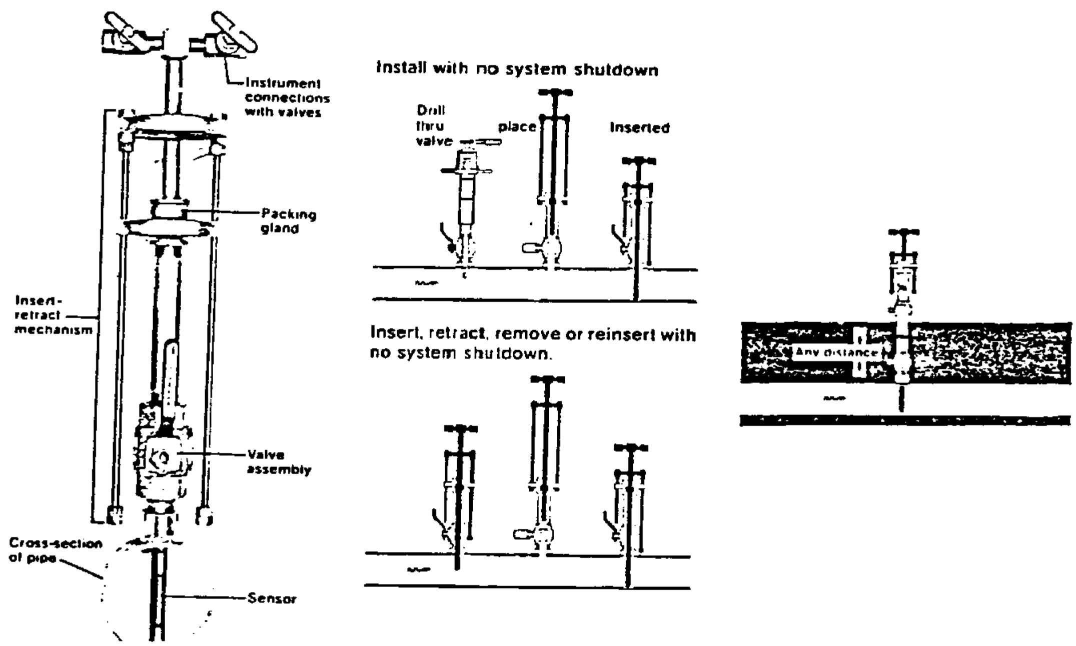


FIGURE 1

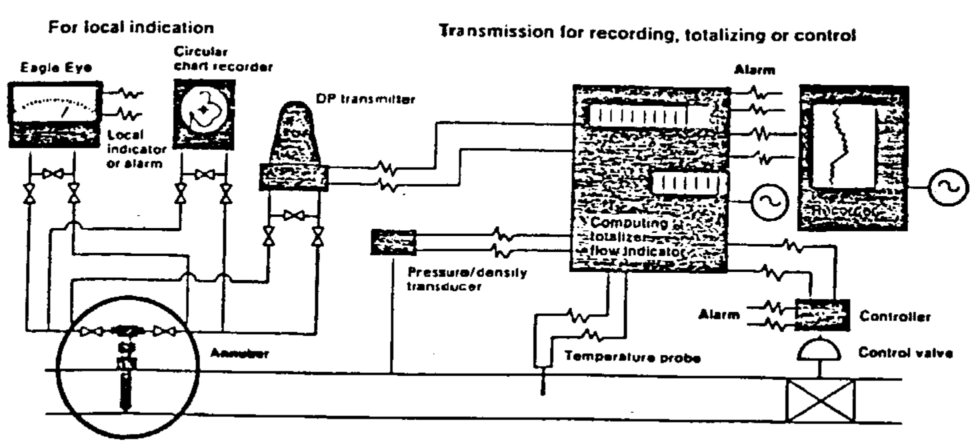


FIGURE 2

PRIMARY FLOW SENSING DEVICE

HOW IT WORKS:

1. The HIGH PRESSURE SENSOR with four impact ports faces upstream. Based on averaging observations, the computer-located ports sense the impact pressure caused by the flow velocity in each of the four equal cross-sectional areas of the flow stream.

2. The INTERPOLATING TUBE inserted within the high pressure sensor transmits the continuous average of the impact (stagnation) pressure detected by the four sensing ports to the high pressure side of the differential pressure measuring device. The impact pressure is the sum of the pressure due to the velocity of the fluid and the line static pressure.

3. The REAR PORT, pointing downstream, senses the low pressure. The difference between the high pressure from the interpolating tube and the low pressure from the rear port is proportional to the flow-rate according to Bernoulli's Theorem. In some sensor models, the rear port is located within the high pressure sensor. In other models, it is located downstream outside the high pressure sensor.

4. The INSTRUMENT HEAD transmits the differential pressure to an Eagle Eye differential pressure flow meter, or other secondary devices, such as a DP transmitter, recorder or controller.

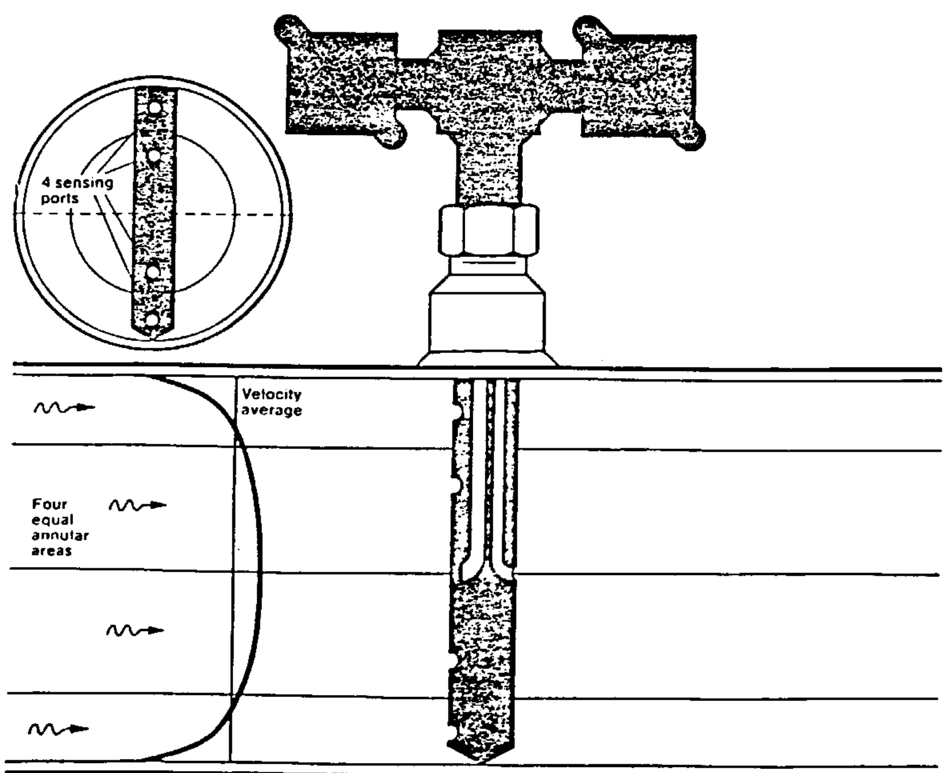


FIGURE 3

TEMPERATURE MEASUREMENTS

Accurate measurement of high temperatures is one of the most critical factors in determining equipment performance and process efficiencies of energy consumption in foundries, high temperatures are defined as those between 700 and 3,500°F.

Sensors used to measure elevated temperatures are classified as either contact or non-contact. Contact sensors include thermocouples, resistance temperature detectors, bimetallic thermometers, thermistors, and filled systems. Non-contactors include optical and radiation pyrometers. Thermocouples are used in 90% of the applications in industrial plants.

Portable thermocouples of various designs are available. The instruments are compact, lightweight, and battery powered, and they can easily be carried around the plant to measure process or equipment temperatures easily. Most models have a variety of interchangeable thermocouples sensors and multiple temperature selector switches to provide maximum versatility. (See table 1 for comparisons).

TABLE 1. COMPARISON OF COMMON THERMOCOUPLES

Type	Usable Temperature Range	Advantages	Restrictions
Type J (Iron-constantan)	-300 to 1600 F	Comparatively inexpensive. Suitable for continuous service to 1600 F in neutral or reducing atmospheres.	Maximum upper limit in oxidizing atmosphere is 1400 F, because of the oxidation of the iron. Protection tubes should be used above 900 F. Protection tubes should always be used in a contaminating medium.
Type K (Nickel, chromium-nickel, aluminum)	0 to 2500 F	Suitable for oxidizing atmospheres. In higher temperature ranges, provides a more mechanically and thermally rugged unit then platinum or rhodium-platinum, and longer life than iron-constantan.	Especially vulnerable to reducing atmospheres, requiring substantial protection when used.
Type T (Copper-constantan)	-300 to 700 F	Resists atmospheric corrosion. Applicable in reducing or oxidizing atmospheres below 600 F. Stability makes it useful at subzero temperatures. Has high conformity to published calibration data.	Copper oxidizes above 600 F.
Type E (Nickel, chromium-constantan)	-300 to 1600 F	Has high thermoelectric power. Both elements are highly corrosion-resistant, permitting use in oxidizing atmospheres. Does not corrode at suozero temperatures.	Stability is unsatisfactory in reducing atmospheres.

TABLE 1. (CONTINUED)

Type	Usable Temperature Range	Advantages	Restrictions
Type S (Platinum, 10% rhodium-platinum)	0 to	Usable in oxidizing atmospheres. Provides a higher usable range than Type K.	Easily contaminated in other than oxidizing atmospheres.
Type R (Platinum, 13% rhoduim-platinum)	2700 F	Frequently more practical than noncontact pyrometers. Has high conformity to published calibration data.	
Type B (Platinum, 30% rhodium-platinum, 6% rhodium)	1600 to 3100 F	Better stability than Type S or R. Increased mechanical strength. Usable at higher temperatures than Type S or R. Reference-junction compensation is not required if junction temperature does not exceed 150 F.	Available in standard grade only. High-temperature limit requires the use of alumina insulators and protection tubes. Easily contaminated in other than oxidizing atmospheres.

BURNER COMBUSTION EFFICIENCY

Conserving fuel in melting, heat treating and ladle heating operations is a complex operation. It requires careful attention to the following:

- Refractories and Insulation
- Scheduling and operating procedures
- Preventative maintenance
- Burners
- Temperature controls
- Combustion controls

Providing the correct combustion controls will increase combustion efficiency measurably. Complete combustion of Natural Gas Yields:

(a) Carbon dioxide

(b) Water vapor

If gas is burned with the chemically correct amount of air, an analysis of the products of combustion will show it contains about 11 to 12% CO_2 @ 20-22% water vapor. The remainder is nitrogen, which was present in the air and passed through the combustion reaction essentially unchanged.

If the same sample of natural gas is burned with less than the correct amount of air ("rich" or "reducing fire"), flue gas analysis will show the presence of hydrogen and carbon monoxide, products of incomplete combustion. Both of these gases have fuel value, so exhausting them from furnaces is a waste of fuel. (See Figure 4).

If more than the required amount of air is used (lean or oxidizing flame), all the gas will be burnt but the products of combustion will contain excess oxygen. This excess oxygen is an added burden on the combustion system - it is heated and then thrown away thereby wasting fuel.

The following steps should be taken to upgrade burner and combustion controls:

1. Use sealed-in burners. Make all combustion air go through the burner - open cage type burners are very inefficient.

2. Use power burners. Inspirator or atmosphere burners have very poor mixing efficiency at low inputs, especially if gas pressure is low.

3. Install a fuel/air ratio control system.

PREMIX BURNER SYSTEMS

Premix burner systems commonly use a venturi mixer known as an aspirator or proportional mixer. Air from the blower passes through the venturi, creating suction on the gas line and drawing in the correct amount of gas at reduced firing rates, air flow is cut back, reducing suction on the gas line, and the amount of gas drawn into the mixer drops in proportion to air flow. Aspirator systems are fairly simple to adjust and maintain accurate fuel/air ratios over wide turndown ranges, but their use is limited to premix burners.

NOZZLE MIX BURNERS

Nozzle mix burners used with a Ratio Regular System is widely used for industrial furnace applications. Orifices are installed in the gas and air lines to a burner and then adjusted so that air and gas are in correct burning proportions when pressure drops across the orifices are equal. Once the orifices are set, they will hold the correct air/gas ratio as long as the pressure drop remains the same, no matter what firing rate. Ratio Regulator Systems have good accuracy and are fairly easy to adjust.

On large furnaces where fuel consumption is extremely high, or on furnaces where very close control of the atmosphere is required, extremely accurate fuel/air ratio control is vital, both for fuel economy and product quality. On these installations hydraulic or electronic flow controls are often used.

These systems feature fixed orifices in both gas and air streams, and these orifices are sized to pass proportional amounts of gas and air at equal pressure drops, pressure drop signals are fed to a ratio controller which compares them. One of the outstanding features of this system is that the fuel/air ratio can be adjusted by turning a dial. Since a burner can be thrown off correct ratios by changes in ambient air temperature and humidity, this ratio adjustment feature permits the operator to set the burner back to peak operating efficiency with very little effort.

On multiple burner furnaces, the combustion products of all burners mix together before they reach the flue gas sampling point (Furnaces should have manifolded flue gas outlets in order to obtain common sampling point for flue gas analysis). If, for example, some of the burners are unintentionally set lean, and others rich, the excess air from the lean burners could consume the excess fuel from the rich burners, producing flue gas with ultimate CO_2 and practically no free oxygen or combustibles. Samples of these gases could be misleading and show correct air/gas ratio, when in fact they are not. Also if a burner is set rich and the excess combustibles in the flue gases find air in the stack and burn there, flue gas analysis will again suggest that the burner is properly adjusted.

To overcome the problem of misleading flue gas analysis in multi-burner furnaces, metering orifices should be installed on the gas lines to each burner. If pressure drops across all orifices are identical, gas flow to eacn burner will be the same.

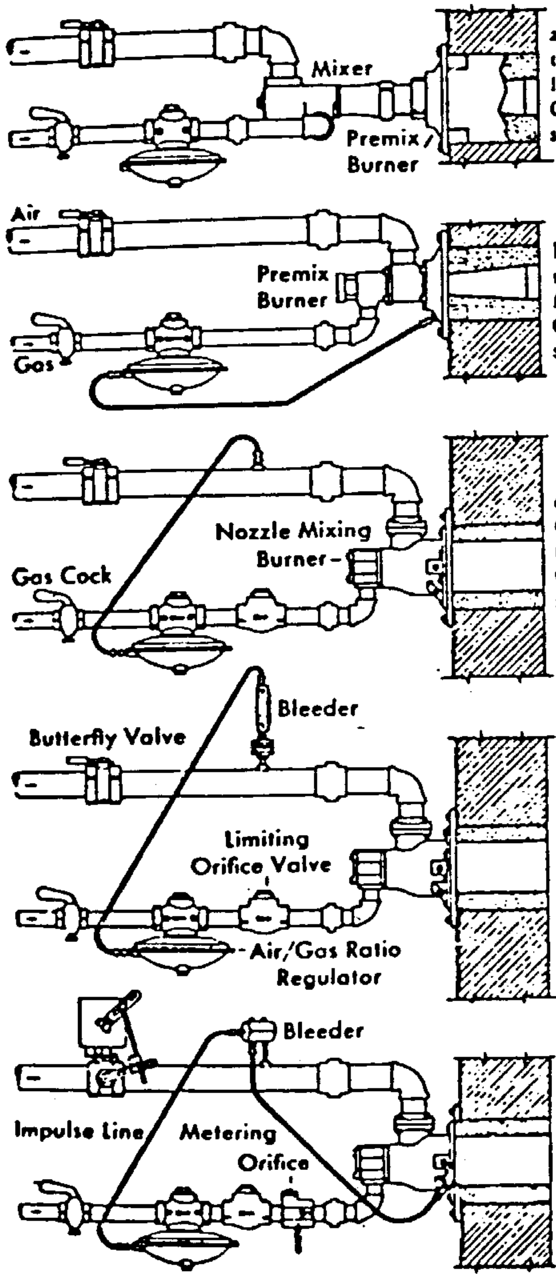
FURNACE PRESSURE CONTROLS

Furnace Pressure Controls will afford additional energy savings, particularly on top-flued furnaces. If a furnace operates under negative pressure, cold air is drawn into it through badly fitted doors and cracks. This cold air has to be heated, adding to the burden on the combustion system and wasting fuel. If the furnace operates at high positive pressure, flames will sting out through doors, site ports and other openings, damaging refractories and buckling shells. Ideally a neutral furnace pressure overcomes both of these problems.

Automatic furnace pressure controls maintain a pre-determined pressure at hearth level by opening or closing dampers in response to furnace pressure fluctuations.

In summation; good fuel/air ratio control equipment and automatic furnace pressure controls are two useful weapons for combating gas energy wastage in heating operations.

Properly applied, they also offer the side benefits of improved product quality and shortest possible heating cycles.



a. Premix Burner (gas suction proportional to air flow). Combustion chamber pressure steady at zero.

b. Premix Burner (gas suction proportional to air flow). Combustion chamber pressure fluctuating.

c. Nozzle Mixing Burner. Gas pressure = or greater than air pressure. Combustion chamber pressure steady or fluctuating.

d. Nozzle Mixing Burner. Gas pressure less than air pressure. Combustion chamber pressure steady at zero.

e. Nozzle Mixing Burner. Gas pressure less than air pressure. Combustion chamber pressure fluctuating. Motor-operated air input control valve and gas metering orifice shown here could also be used in a, b, c and d.

TYPICAL GAS/AIR REGULATOR HOOK-UP

PERCENT EXCESS AIR FROM CO_2 READING

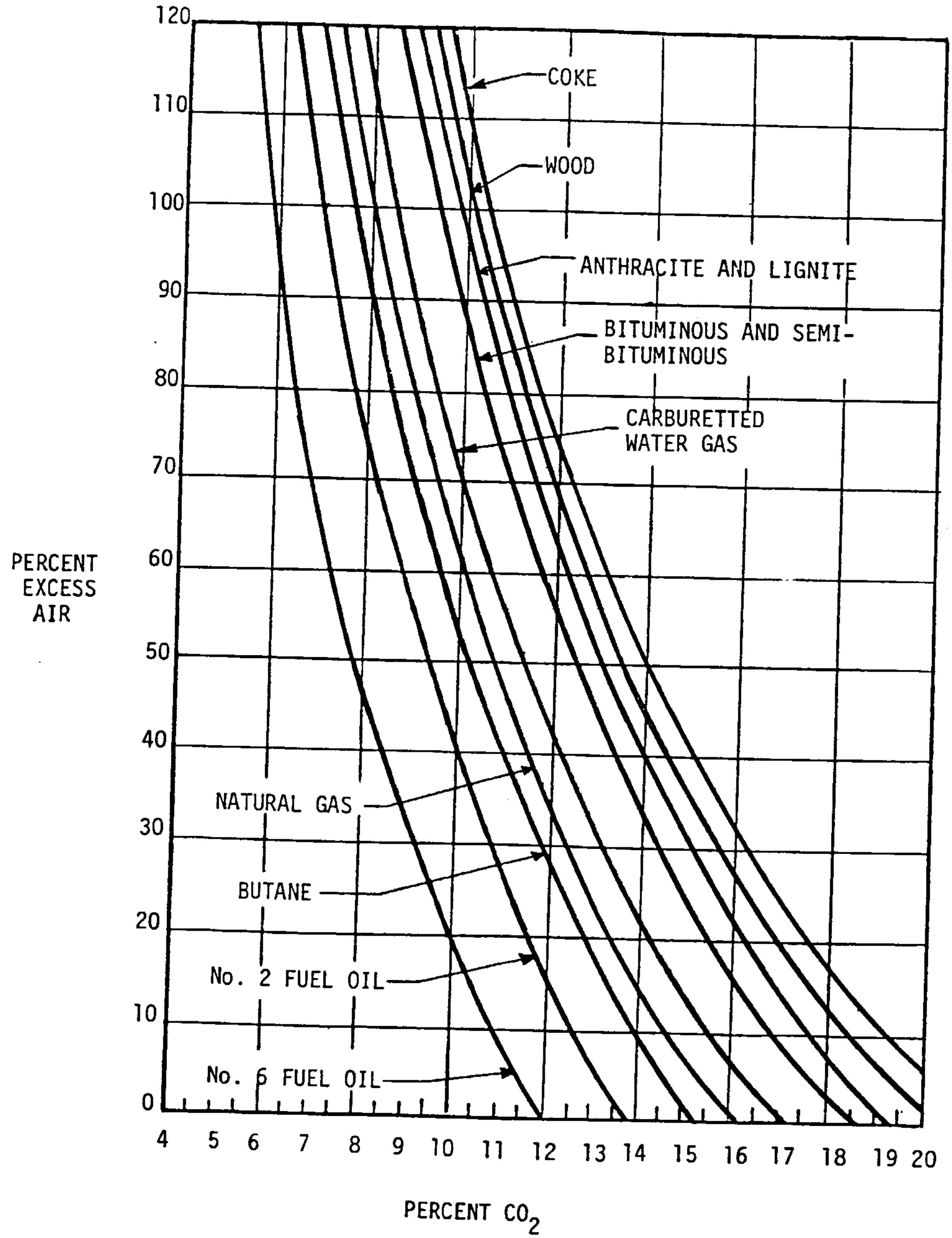


FIGURE 4

FURNACE EFFICIENCY

Conventional refractory linings in heating furnaces have poor insulating abilities and high heat storage characteristics. There are two basic methods available for reducing heat storage effect and radiation losses in melt and heat treat furnaces; they are:

1. Replace standard refactory linings with vacuum-formed refractory fiber insulation material.

2. Install fiber liner between standard refractory lining and shell wall.

3. Install ceramic fiber linings over present refractory liner.

The advantages of installing refractory fiber insulation are:

- Refractory fiber materials offer exceptional low thermal conductivity and heat storage. These two factors combine to offer very substantial energy savings in crucible, reverberatory and heat treat furnaces (documented savings - 35% or better).

- With bulk densities of 12-22lbs/cu ft, refractory fiber linings weigh 8% as much as equivalent volumes of conventional brick or castables.

- Refractory fibers are totally resistive to damage from drastic and rapid changes in temperature.

- Fiber materials are simple and fast to install.

- The density of fiber refractory is low, so there is very little mass in the lining, therefore much less heat is supplied to the lining to bring it to operating temperature. This resuts in rapid heating on start-up. Conversely, cooling is also rapid, since there is less heat stored in the lining.

- Foundries have reported as much as double the crucible life with fiber lined furnaces. Greater temperature uniformity is one of the key factors in attaining this advantage.

- More comfortable working environment is attainable due to lower shell surface temperatures.

The basic design criteria for fiber lined crucible furnaces are the same as used for furnaces lined with dense refractories. Two rules should be followed:

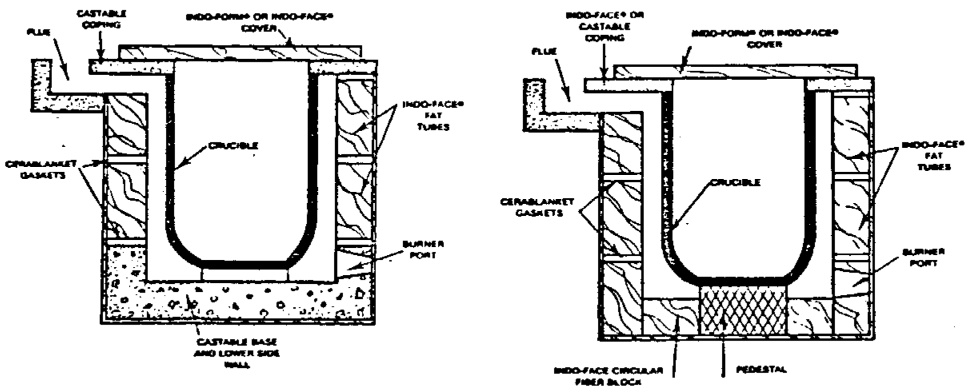
1. The midpoint of the burner should be at the same level as the bottom of the crucible, and the burner should fire tangentially into the space between the crucible and lining.

2. The space between the outside of the crucible, and the furnace lining near the top should be about 10% of the crucible diameter.

Crucible furnace can be constructed using a combination of fiber with dense refractory or almost entirely out of fiber. Increasing the proportion of fiber will increase the energy savings and maximize the other benefits previously listed.

Fiber materials are available in varying thicknesses, suitable for a complete monolithic installation, and composition to handle 2,400°F, 2,600°F, and 2,800°F.

The higher termperature compositions contain high alumina fiber, which lowers the amount of shrinkage at elevated operating temperatures.



TYPICAL FIBER LINING DESIGNS

FURNACE COVERS

If preheating of combustion air utilizing furnace flue gas temperatures is contemplated, installation of furnace covers is mandatory. The difficulty in the past, in the fabrication and use of furnace covers, has been the problems of thermal shock and spalling, materials available today, such as refractory fiber, have eliminated these problems.

In addition to technological advantages of fiber insulations, industry has also developed the capability of vacuum forming these materials over a variety of metallic support structures. Fiber insulation can be formed over either expanded metal or angle iron frames, or both, with v-type anchors attached. The anchors are made from high temperature alloys, holding the fiber to the metallic support structures to provide an integral, fully secured assembly. No part of the anchor system is exposed to excessive temperatures, this eliminates attachment problems for ladle pre-heaters, crucible furnace covers, and induction furnace covers. Installation of furnace covers improves the thermal efficiency of the process by approx. 50%.

CRUCIBLE POT AND REVERBERATORY FURNACES

Non-Ferrous Foundries utilize three basic furnace types for melting and holding. They are:

- Gas fired crucible
- Gas fired reverberatory
- Electric reverberatory

1. The stationary crucible furnace is primarily used for aluminum, copper, and brass alloys. Its versatility to alloy changes makes it a desirable furnace for small foundries where such metal changeover is necessary. Combustion burners are located so the flame is tangential to the crucible in order to avoid direct flame impingement against the crucible wall. Biggest disadvantage other than thermal efficiencies are short crucible life which affects bath temperature controllability.

2. Fuel fired reverberatory is usually chosen when melt rate and/or capacity is such that a crucible would be too small. The reverberatory is direct fired from either the roof or sidewall with gas, propane, or oil burners (for the purpose of this study the relative cost per BTU is assumed as being equal). The heat is transfered to the bath by a combination of convection and radiation.

3. Electric reverberatory furnaces - see discussion under "Major Process Changes" Part H Section I.

UPGRADING GAS FIRED FURNACES

1. Replace brick or castable refractory with vacuum-formed refractory fiber on gas fired crucibles.

   Arrow Casting and Development Co., in Santee, California, installed fiber liners on two-425 lb. crucibles - documented 35% saving in fuel. They can now produce a melt in one hour from cold start as compared to 2-1/2 hours with conventional refractory liner-payback period - 6 months.

   Other advantages:

   - Faster turn around time at reline time
   - Lower shell temperatures (500 to 350°F)

   Arrow specializes in alloy 356 racing car safety components.

2. Add fiber insulated liner between standard refractory liner of shell casing.

3. Update combustion controls (see burner combustion efficiency discussion - Page B-8).

4. Install furnace covers (see prior discussion - Page B-14).

5. Other miscellaneous changes that can be accomplished to improve furnace efficiencies.

   - Reduce flue openings to a minimum, the correct design is 20-30,000 BTU per square inch

   - Optimize burner equipment maintenance

   - Maintain clean blower filters

   - Keep flues and slag hole clear

HEAT TREAT FURNACES

Heat treating is the second most energy intensive operation in the foundry. A comprehensive energy management program is mandatory as gas and oil costs continue to grow and diminish in supply.

Many heat treat facilities in the foundry industry are not particularly in good operating shape. Minimum attention is paid to combustion efficiency and refractory maintenance.

Upgrading heat treat furnaces in the following areas will yield tremendous fuel savings:

- Replace existing burners with a modern pre-mix burner system

- Install efficient burner controls

- Install furnace pressure controls

- Replace conventional refractory lining with fiber insulation 1/ 2/

- Seal all cracks and openings in casing and doors

- Install combustion air pre-heat system

Each of the above categories is related and dependent upon the state of the others, but will show an energy savings when individual improvements are made. Energy savings can be considered additive when an all out improvement program is implemented.

Process Operation and Control: Heat treat operations fall into two major categories - continuous and batch type. Ignoring specific casting requirements, restricting one process over the other, the continuous operation is favored from an energy conservation standpoint. With continuous operation, the furnace remains in equilibrium and is not heated and cooled and reheated with every new batch processed. The heat required to bring refractory up to various furnace temperatures and the heat lost through the furnace walls to the surrounding ambient temperature, based on varying thicknesses of refractory, is illustrated:

HEAT STORAGE AND LOSSES BTU SQ.FT.

WALL THICKNESS	TYPE REFRACTORY	HOT FACE TEMPERATURE °F					
		1,200		1,600		2,000	
		H. ST.	H.L.	H. ST.	H.L.	H.ST.	H.L.
9"	Composite 2,000° insulation and firebrick	13,700	285	19,200	437	24,800	615
13-1/2"	Composite 2,000° insulation and firebrick	22,300	335	31,400	514	40,600	718
22-1/2"	Composite 2,000° insulation and firebrick	43,200	182	61,000	281	79,200	392
6"	Ceramic fiber	842	208	1,170	432	1,490	672

Condensed from Mark's handbook
H.ST --- Amount of heat stored
A.L --- Amount of heat lost (Btu/Sq Ft)

The following information of present operating characteristics are necessary in evaluating present furnace efficiencies:

- Fuel flow rate in cubic feet per hour (gas) and gallons per hour (oil).
- Gas or oil usage (by metering) per operating day or week (preferably from fire-up to shut down).
- Casting through put in tons per hour for the same period.
- Fuel cost in dollars per million BTU's.
- Operating cycle, hours per load, and casting load in tons.
- Furnace operating temperature, waste flue gas temperature, and outside shell temperature.
- Types of existing burners, ratings, and percent of excess air (determined by flue gas analysis).

The above information can be used to determine existing heat input in BTU's per pound of castings processed and, calculate the anticipated heat input after replacement or renovation of existing furnaces. Such calculations form the basis of returns on investment calculations that will permit a decision based on economical justification.

Footnotes:

1/ "Furnace lining cuts annealing costs 30%."
Reference: Foundry M&T Magazine - February 1977
Kingsford Foundry and Manufacturing Company, Kingsford, Tenn.: Installation of ceramic fiber on their batch type annealing ovens cut gas consumption by 68% which represented a cost savings of $8,900 per year. The furnace measures 10 ft wide by 23 ft long inside by 10 ft high - 45,000 lb annealing lots.

2/ "Buckeye Steel Cuts Natural Gas Usage"
Reference: Foundry M&T Magazine - April 1976
Buckeye can produce up to 7,000 tons of castings per month, their consumption of natural gas for heat treating is considerable. Eleven car bottom heat treat furnaces when relined with fiber insulation - fuel consumption was reduced by approximately 40%. Other benefits cited by Buckeye are:

- Furnace heat up time cut from 12 hrs to 45 minutes
- Cooldown is rapid enough so that another car can go into the furnace in 15 minutes.

LADLE HEATING

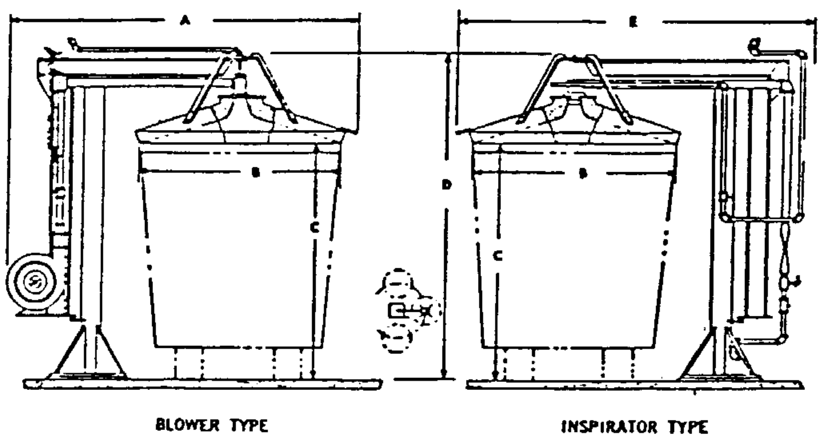
The third largest gas consumming process in the foundry industry is ladle preheating. Most foundries use open ladles with Torch Type Gas Burners which consume gas during periods when no ladle preheating is taking place. Upgrading present ladle heating methods utilizing the following recommended procedures will result in dramatic gas energy savings:

- Change unregulated Torch Type Burners to gas/compressed air type regulators.
- Install insulated covers.
- Add insulated fiber lining between conventional refractory and shell.

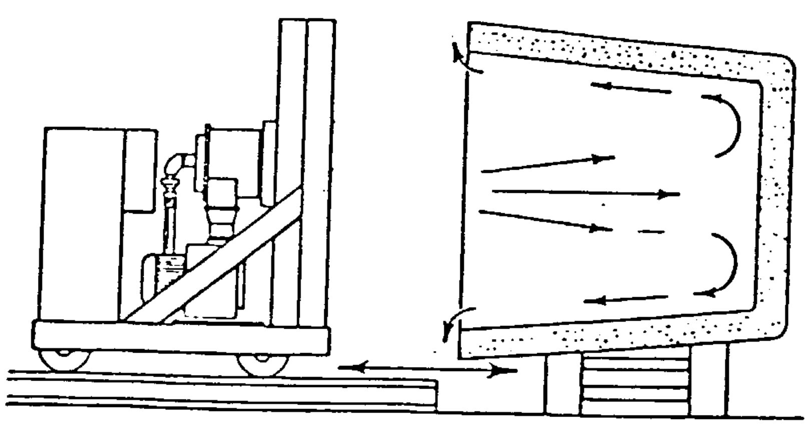
Ladles come in numerous sizes and shapes, lined with castable or brick refractory or a combination of both. They are first heated slowly to expell moisture, without damaging refractory, until they are dry, then the heating rate is increased to allow refractory surface temperature to reach 2,000° to 2,400°F, primarily to reduce thermal shock to the lining and reduce temperature losses of the metal during pouring. Ladle practices vary largely from one cast metal facility to another. The practice is always energy intensive and what used to be good practice of a well operated shop, to have clean-heated ladles on standby at all times, is poor practice from the standpoint of energy management. The situation of high energy losses becomes progressively more serious when foundries use ancient, delapidated, or homemade gas torches versus the latest state-of-the-art combustion equipment.

Ladle Heating Equipment may be oil or gas fired or a combination of both; electric ladle heating is discussed under "Major Process Changes". See Section I Part H.

Generally, more efficent heating and drying systems and practices are possible in shops using large ladles where fixed ladle heating stations with covers or hotwalls with fully piped burners are being used. The following diagrams show examples of fixed and wall type ladle stations.



FIXED TYPED LADLE STATION



WALL TYPE LADLE STATION

With many small foundry operations, the logistics and number of ladles handled make it difficult to maintain fixed burner stations using full air/gas controls. Often portable torches are propped up on the ladle rim, gas flow rates are regulated by means of manual ball or gate valves. Gas consumption can be reduced by two thirds if regulated compressed air is added.

A foundry in the midwest installed regulated compressed air in a 500 pound ladle for drying and heating, they now use 220 cu. ft. of natural gas per hour compared with 660 cu. ft. when using open gas torch only.

The other option for smaller foundries is to substitute electric ladle heaters - see Section I Part H for further discussion relative to electric versus gas ladle heating.

Potential indirect energy reduction, due to control of metal temperature in the ladle by utilization of insulation and covers, is possible due to control of pouring defects from cold metal and reduction in super heat necessary for metal to be available at optimum pouring temperature when tapped from the furnace.

The possibilities of such savings and increased production make it worthwhile to carefully analyze hot metal handling systems and ladle selections, with the aim of eliminating excessive losses of temperature caused by unnecessary transfers of metal, improper distribution schedules, and inadequate ladle insulation.

PART C

COKE AND SUPPLEMENTAL FUELS

USE IN FOUNDRIES

Cupolas are coke-fired counterflow heat exchangers for melting iron. Energy statistics published by the AFS and other organizations show that, on the average, iron foundries using cupolas consume approximately half of their total energy in the cupola. Based on material input to the melting operation, Figure 1 and Table 1 show energy use in the cupola (National Basis) per net ton of good castings.

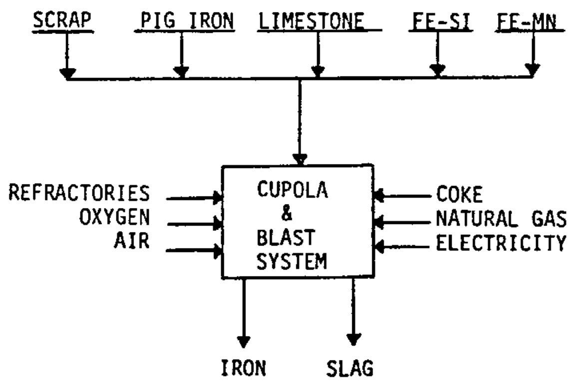


FIGURE 1. MATERIALS AND ENERGY USED IN CUPOLAS

TABLE 1. ENERGY USE IN CUPOLA (NATIONAL BASIS)

	Million Btu per net ton of good castings shipped(a)
Coke (13% of metallics)(b)	7.76
Transport	0.08
Natural gas	1.60
Electricity(c)	1.05
Scrap	0.00
Transport	0.17
Pig iron	4.17
Transport	0.06
Limestone	0.02
Transport	0.01
FeSi	2.28
Transport	0.01
FeMn	0.75
Transport	0.01
Refractories	0.50
Transport	0.01
Oxygen	0.11
Transport	0.01
TOTAL	18.60

(a) 60% yield from molten iron to good castings shipped.
(b) 33 million Btu/net ton of coke.
(c) 10,500 Btu/kwh.

FOUNDRY COKE

Foundry coke is a solid, cellular residue obtained when certain bituminous coals are heated, out of contact with air, above temperatures at which active thermal decomposition occurs. Coke formed by heating above 1,652°F is called high temperature coke.

Typical foundry coke blends:

TABLE 2. SOME TYPICAL FOUNDRY COKE BLENDS AND COKING CONDITIONS

Plant	Blend, %			Pulv'n[1]	Coking Time[2] in./hr	Flue Temp. Ave. °F	Coke Temp.[3] °F
	Low Vol. Coals	High Vol. Coals	Inert[4]				
A	30.5	56.5	13	80	1.1	2,500	1,800
B	34	60	6	85	0.7	2,200	1,860
C	32	59	9	80	1.1	2,610	1,800
D	50	50	0	88	0.65	1,800	1,750
E	38	56	6	90	1.1	2,300	--

1 Percentage passing 1/8-in screen.
2 Oven width in inches divided by coking time in hours.
3 Average coke temperature calculated from hydrogen content (see "Chemical Tests" in this chapter).
4 Selected anthracite fines meeting foundry coke size and gravity specifications[15].

SUPPLEMENTARY FUELS

Anthracite coal is a dense, hard, natural product ranging in fixed carbon content from 85-87% compared to 90-93% for coke.

Major material properties are:

	Anthracite	Coke
Ash	8 - 10%	6 - 8%
Volatiles	4.5 - 5.5%	0.4 - 0.7%
Sulfur	0.4 - 0.65%	0.60 - 0.70%
Heat content (Btu/lb)	13,000 - 13,900	12,500 - 13,500
Material density lbs/ft^3	53 - 58	26 - 32

The greater density gives more energy per volume of space occupied by the coal in the cupola; however, the nonporous nature causes slower burning.

Usage of anthracite coal up to 25% of the total fuel has been reported (Ref. W. J. Peck, Central Fdy Div GMC., Defiance) with some modification necessary to cupola operation and careful control of material size.

If oxygen enrichment is also available, the use of greater than 25% coal may be feasible.

STORAGE

It is common practice at many foundries to store coke in the open. No appreciable deterioration results in mild weather, but when exposed to alternate freezing and thawing, the size can be degraded due to water freezing in the coke fissures. Also, moisture content of coke increases if not stored under cover resulting in increased energy usage to dry the coke charged in the cupola.

OTHER FUELS

Supplementary cupola charge fuels are in use. Coke breeze is used as briquettes or direct injection through the tuyeres.

Table 3 shows typical analysis and sizing of the injection grade coke fines being used in a typical injection system. The substitution of injected coke fines for charge coke has resulted in reduction of charge coke by as much as 20% (Ref. H. J. Christensen, Petrocarb Inc., N.J.). Replacement ratios of coke removed versus fines injected range from 1:1 and 1.5:1, that is to say, more coke is removed than fines injected with the corresponding cost reduction for materials.

TABLE 3. COKE FINES SPECIFICATIONS

SIZING:	10 MESH X 0	
PROXIMATE ANALYSIS:	Fixed Carbon	88.0%
	Ash	11.0%
	Volatile	1.0%
	Sulfur	0.60%
	Moisture	-1.0%

TABLE 4. COKE SUBSTITUTION VALUES FOR THREE CUPOLA OPERATIONS USING COKE FINES TUYERE INJECTION

CUPOLA	CUPOLA DIAMETER	BLAST TEMP °F	OXYGEN ENRICHMENT	SCFM BLAST RATE X 1,000	MELT RATE TONS/HOUR	% COKE CHARGED	% SUBSTITUTION OF CHARGED COKE	SUBSTITUTION RATIO POUND(S) OF COKE REMOVED TO EACH POUND OF COKE FINES INJECTED	
A	122"	1,200	2%	25-27	50-60	12%	13%	1.3	1
B	108"	950	INTERMITTENT	18	35	15.8%	11.4%	1.6	1
C	46	NO	YES		10	19.5%	10.3%	1.25	1

CUPOLA MODIFICATIONS

Blast conditioning, to provide sensible heat in the air supply to the cupola, can be arranged through recuperator systems and preheat burners. Hot blast systems operate at 500 - 1,200°F. Addition of oxygen, in amounts of 2 to 4 percent of blast air, is carried out to increase tap temperature, improve melt rate, or reduce coke usage.

Dividing blast, or separation of tuyers into two rows with approximately 36 inches between rows, has been proven to increase the depth of melt zone in the cupola which results in higher tap temperature, reduction in coke usage, or increased production.

Some metallurgical changes occur with both oxygen enrichment and divided blast systems, but proper controls and adjustments in charge make-up or alloy additions can compensate for this.

Detailed analyses of alternates are covered in further sections of this study.

PART D

WASTE HEAT RECOVERY SYSTEMS

GENERAL CONSIDERATIONS

The first step in heat recovery analysis is to survey the foundry and take readings of all recoverable energy that is being discharged to atmosphere. The survey should include analysis of the following conditions:

- Exhaust stack temperatures
- Flow rates through equipment
- Particulates, corrosives of condensible vapors in the air stream

Ventilation, process exhaust and combustion equipment exhausts are the major sources of recoverable energy.

Table 1 illustrates typical energy savings achieved by preheating combustion air with hot exhaust gases from process or furnaces.

TABLE 1. FUEL SAVINGS REALIZED BY PREHEATING COMBUSTION AIR*

Furnace outlet temperature, F	Fuel savings, percent, when combustion air preheat temperature, F, is: 400	500	600	700	800	900	1000	1100	1200	1300	1400
2600	22	26	30	34	37	40	43	46	48	50	52
2500	20	24	28	32	35	38	41	43	45	48	50
2400	18	22	26	30	33	36	38	41	43	45	47
2300	17	21	24	28	31	34	36	39	41	43	45
2200	16	20	23	26	29	32	34	37	39	41	43
2100	15	18	22	25	28	30	33	35	37	39	41
2000	14	17	20	23	26	29	31	33	36	38	40
1900	13	16	19	22	25	27	30	32	34	36	38
1800	13	16	19	21	24	26	29	31	33	35	37
1700	12	15	18	20	23	25	27	30	32	33	35
1600	11	14	17	19	22	24	26	28	30	32	34
1500	11	14	16	19	21	23	25	27	29	31	33
1400	10	13	16	18	20	22	25	27	28	30	--

* Natural gas with 10 percent excess air; other charts are available for different fuels and various amounts of excess air.

Regardless of the amount or temperature of the energy discharged, recovery is impractical unless the heat can be effectively used elsewhere in the foundry. Also, the recovered heat must be available when it is needed; if not, some sort of heat storage equipment is necessary which will increase the capital cost expenditure and minimize the return on investement.

Waste heat recovery can be adapted to several applications:

- Space heating
- Make-up air heating
- Water heating
- Process heating
- Combustion air preheating
- Boiler feed water heating
- Process cooling or absorption air condtioning
- Charge preheat
- Scrap preheating

The need for comfort heating and make-up air heating systems in foundries located through-out California, for the most part, is non-existant - therefore this study will limit its discussion to combustion air preheating as it relates to waste heat recovery. There will be isolated instance where fairly large process air conditioning systems and process steam heating systems are utilized, as in investement casting facilities, therefore an overview of the various heat recovery devices available will be presented which will cover:

- Air to air heat exchangers
- Air to liquid heat exchangers
- Liquid to liquid heat exchangers

TYPES OF HEAT RECOVERY EQUIPMENT

Choosing the type of heat recovery device for a particular application depends on the three factors determined in the plant survey, for example air to air equipment is the most practical choice if the point of recovery and use are close coupled. Air to liquid equipment is the logical choice if longer distances are involved.

This study addresses five types of heat recovery equipment:

- Economizers
- Heat pipes

- Shell and tube heat exchangers
- Regenerative units
- Recuperators

Economizers

Economizers are air to liquid exchangers. Their primary application is to preheat boiler feed water. They may also be used to heat process or domestic water, or to provide hot liquids for space heating or make-up air heating equipment. (See Figure 1)

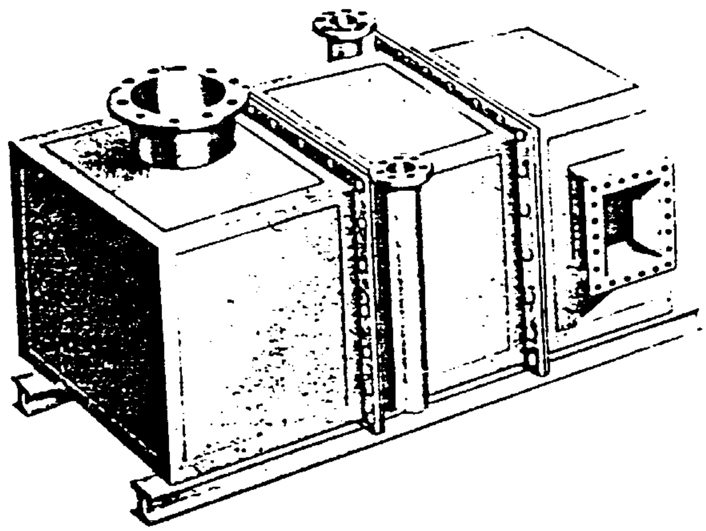


FIGURE 1. TYPICAL ECONOMIZER

The basic operation is as follows: Sensible heat is transfered from the flue gases to the deaerated feed water, as the liquid flows through a series of tubes in the economizer, which is located in the exhaust stack.

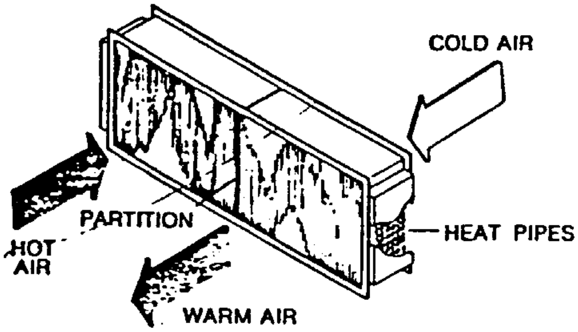
Most economizers have finned tube heat exchanges constructed of carbon steel and tube sheets, stainless steel while the inlet and outlet ducts are carbon steel lined with suitable insulation. Maximum recommended waste gas temperatures for standard units is 1,800°F.

According to economizer manufacturers, fuel consumption is reduced approximately 1% for each 40°F reduction in flue gas temperature. The higher the flue gas temperature the greater potential for energy savings.

Heat Pipes

The heat pipe thermal recovery unit is a counter flow air to air heat exchanger. (See Figure 2)

Hot air is passed through one side of the heat exchanger and cold air is passed through the other side in the opposite direction.



~~FIGURE 1~~

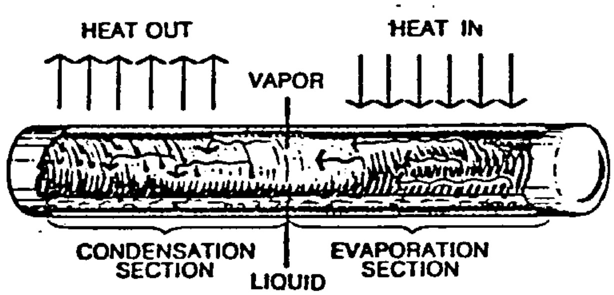


FIGURE 2. TYPICAL HEAT PIPE CONFIGURATION

Heat pipes are usually applied to process equipment in which discharge temperatures are between 150° and 850°F. There are three general classes of application for heat pipes:

(a) Recycling heat from a process back into a process (process to process)

(b) Recycling heat from a process for comfort and make-up air heating (process to comfort)

(c) Conditioning make-up air to a building (comfort to comfort)

Heat pipes recover between 60 to 80% of the sensible heat between the two air streams. A wide range of sizes are available, capable of handling 500 to 20,000 cu ft of air per minute. The main advantages of the heat pipe are:

- No cross contamination
- Operates without external power
- Operates without moving parts
- Occupies a minimum of space

Shell and Tube Heat Exchangers

Shell and tube heat exchangers are liquid to liquid heat transfer devices. There primary application is to preheat domestic water for toilets and showers or to provide heated water for space heating or process purposes. (See Figure 3)

The shell and tube heat exchanger is usually applied to a furnace process cooling water system, and is capable of producing hot water approaching 5° to 10°F of the water temperature off the furnace.

To determine the heat transfer capacity of the heat exchanger the following conditions of the operation must be known:

- The amount of water to be heated in gallons per hour
- The amount of hot process water available in gallons per hour
- Inlet water temperature and final water temperature desired
- Inlet process water temperature

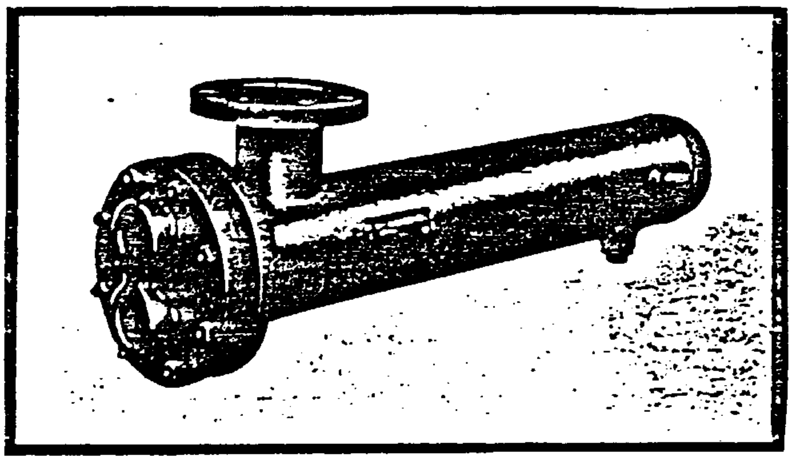


FIGURE 3. TYPICAL SHELL AND TUBE HEAT EXCHANGER

Regenerative Unit (Heat wheel)

The heat wheel is a rotary air to air energy exchanger which is installed between the exhaust and supply air ductwork in a make-up or air heating system. It recovers 70 to 90% of the total heat from the exhaust air stream. (See Figure 4)

Glass fiber ceramic heat recovery wheels can be utilized for preheating combustion air with exhaust flue gases as high as 2,000°F.

Heat wheels consist of: rotating wheel, drive mechanism, partitions, frames, air seals and purge section. Regeneration is continuous as energy is picked up by the wheel in the hot section, stored and transfered to the colder air in the supply section as the wheel rotates through it.

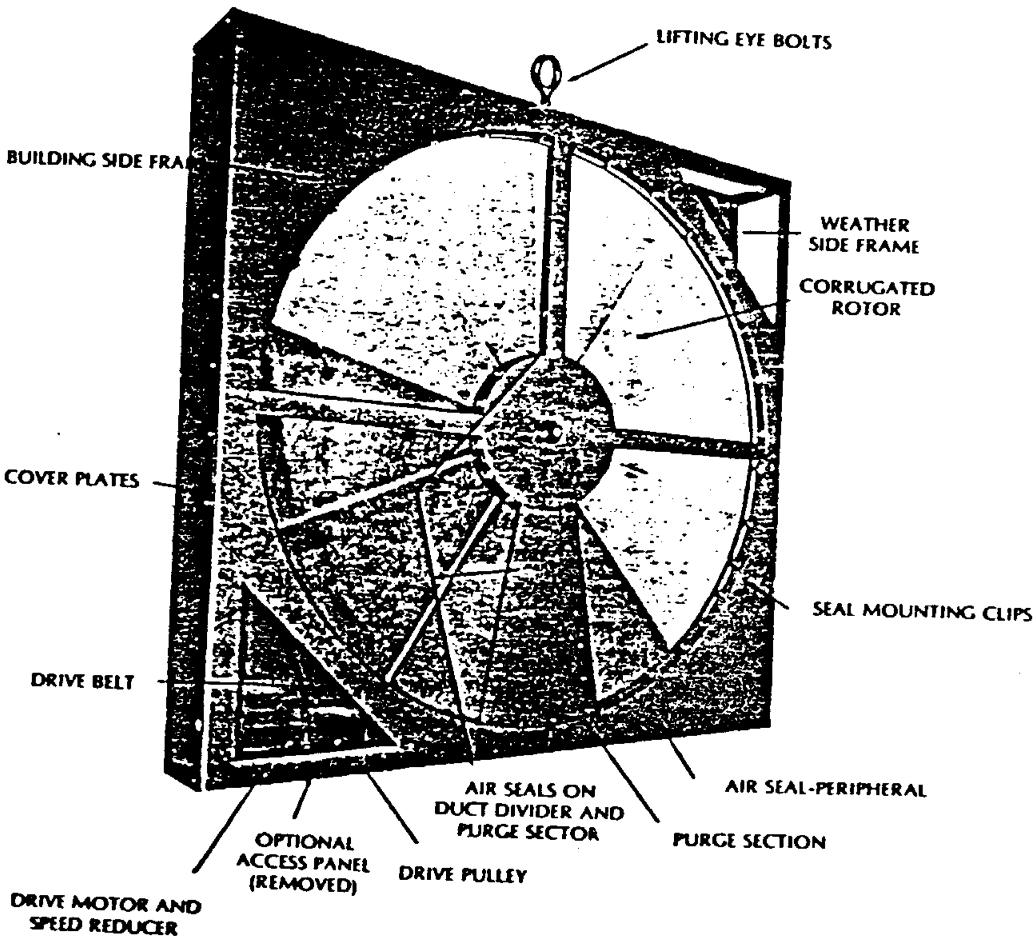


FIGURE 4. TYPICAL HEAT RECOVERY WHEEL

Recuperators

Recuperators are air to air heat exchangers built to provide efficient transfer of heat from hot exhaust gases to a cooler air stream.

Recuperators are generally used in the following processes:

- Preheating combustion air
- Preheating scrap metal
- Provide hot blast at cupola's
- Recovery heat from hot gas to suppliment or replace the primary heat source in process or comfort heating applications

There are many different types of recuperator designs available today. The recuperator illustrated in Figure 5 is primarily used for combustion air preheating. It consists of three basic cylinders, the hot gases flow up though the inner cylinder, cold combustion air enters at the bottom of the outer cylinder, flows upward and down through the middle cylinder, exiting from the bottom of the middle cylinder.

Heat energy from exhaust gases is transfered through the inner cylinder wall to the combustion air by a combination of conduction and radiation heat transfer. The net effect is preheated air temperatures as high as 1,000°F with inlet exhaust gases entering at 2,000°F and exiting at 1,300°F.

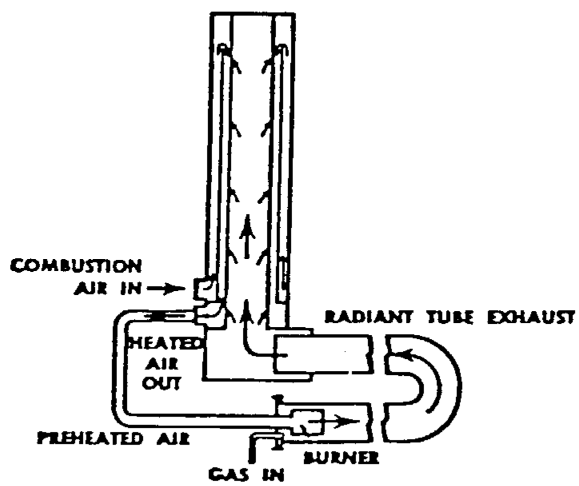


FIGURE 5. OPERATING PRINCIPLE

PART E

PROCESSES OF SECONDARY IMPORTANCE

As previously stated, approximately 20% of the plants energy input is consummd in secondary processes - no attempt has been made to quantify energy savings in these areas except where actual percentages can be quoted from other sources.

CLEANING AND FINISHING

Material handling, welding, grinding, inspection, and painting processes comprise the minor energy using activities remaining after major heat treatment usage. Other areas where additional energy can be conserved:

1. Compressed air tools and hoists require frequent servicing to maintain efficiency. Adequate lubrication is essential to reduce friction in high velocity air motors.

2. Air hoses should be sizes for minimum pressure drop to air tools, a 10% drop from designed supply air pressure of 90 psi results in 15% reduction in production output.

3. Replace air driven equipment with induction motors where practical. If a high pressure induction motor is required to produce 5 cfm at 100 psi pressure, an equivelent vane type air motor would consume 25 cfm at the same pressure requirement.

4. Check and replace worn sand blast air nozzles to reduce air consumption. 5/16" nozzle worn to 3/8" diameter will consume an additional 65 to 70 cfm.

5. Welding units of the motor generator type should be shut down when not in use. Smoke detector activated exhaust fans over welding area will reduce unnecessary loss of in-plant heated air and power consumption. When using coated electrode-metal arc welding, use the largest diameter electrode possible to improve efficiency.

EXAMPLE

Rod size	Current	kW	Deposition	Welded Efficiency
1/8"	110a.	5.6	.87#/hr.	47%
3/16"	150a.	7.65	1.32#/hr.	51%
1/4"	250a.	13.65	2.50#/hr.	55%

6. Paint lines should use airless spray guns. It requires 9.5 HP to atomize 1 gpm using air spray, compared to approximately 1.3 HP for airless type.

7. Consider direct fired paint drying ovens instead of indirect. The heat transfer coefficient for direct fired is about 97% vs. 60% for indirect.

8. Water hose spray has been reported to cut overall natural gas consumption for drying up to 45%.

9. Install insulation on paint line heated wash and pretreatment tanks. For instance, an uninsulated vessel at 200^oF can waste up to 315 BTU/hr/sq. ft. Investigate using recovered process heat as source for paint line heating requirements. Schedule paint line for continuous period of operation rather than frequent shut downs and start ups. Robot painting manipulators can be programmed to start and stop cycle as required.

10. Fork truck idling time and use of oversize vehicle for job wastes energy. Install door opening and closing devices operatable by truck driver in the operating seat. If possible, install double air lock doors. In large facilities use portable radios to direct fork trucks to next assigned area to reduce empty trips.

MOLD AND CORE MAKING

The following modifications, changes, and additions to mold and core making operations to effect energy savings are:

1. Install manual shut-off valves on each gas distributing line on shell core making machines.

   A foundry in the midwest installed valves to control the flow of gas to each row of burner tips. Their objective was to use only as many gas tips as were required to heat the core box. By cutting off one row of burner tips, their energy savings amounts to 256×10^6 Btu per year.

2. Convert from hot box phenolic resin cores to cold box cores.

   The same foundry as in (1) above saved gas in the amount of 1.170 Btu per pound of core or 675×10^6 Btu per year. In addition, they produced the cold box cores about three times as fast as the hot box cores.

POURING AND SHAKEOUT

The following modifications, changes and additions to pouring and shakeout operations to effect energy savings are;

1. Excessive lighting levels over areas of mold cooling and incandescent lights used at work stations can be changed to reduce energy. Reported improvements of up to 15% were obtained by switching to high-pressure sodium lighting at a New Haven foundry.

2. Movement of clean waste heat to where it is needed can be profitable by recovery of heat from molds and cooling areas for process heat in other areas.

3. Pouring yield, that is, the effective weight of castings per mold relative to gross metal poured into the mold, is an important statistic indicating efficiency of pattern layout and gating techniques.

An improvement in pouring yield from 40% to 45% reduced energy in remelting the returns approximately 9% at Hayes Albian and even at 60% yield, about 40% of melt energy is being dissipated by recycling of metal within the foundry.

4. Shakeout systems operating with no load and excessive sand to metal ratios consume energy with no increase in production.

COMPRESSED AIR SYSTEMS

A number of simple guidelines, if effectively followed, can save foundries significant amounts of energy through conservation of compressed air.

Conservation measures are especially needed to increase the efficiency of pneumatic cylinders. Some foundries have oversized cylinders and longer than necessary strokes. Only one cylinder size is correct for any given application and knowledgeable suppliers can provide the information necessary to determine the correct cylinder for any specific operation.

Example: A foundry presently is using a 3-1/4" x 6" diameter cylinder for one of their plant air compressors. Consultation with the compressor manufacturer resulted in changing to a 2" x 4" diameter cylinder. Air consumption per cycle at 100 psi pressure was recorded for each cylinder size as follows:

- Correct cylinder --- 0.108 SCF
- Oversized cylinder --- 0.428 SCF

Use of higher pressure than those required wastes considerable compressed air; limiting pressures to the desired level with quality regulators quickly repays the initial investment. Figure 1 shows effect of different line pressures.

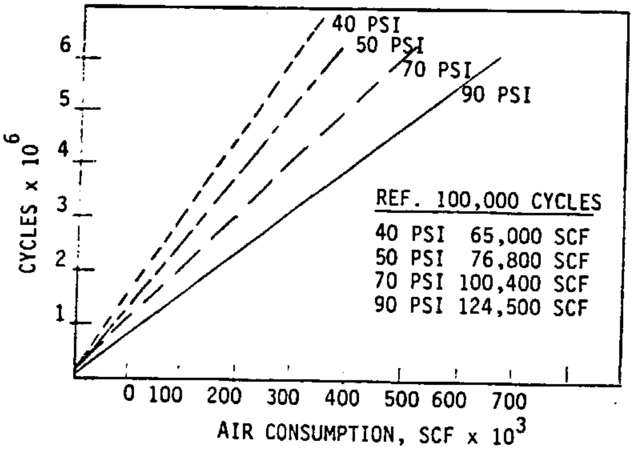


FIGURE 1. HOW LINE PRESSURE AFFECTS AIR CONSUMPTION

A large percent of cylinder and rotary actuator applications require maximum thrust in one direction only and the return stroke can be made with greatly reduced pressure -- this is true with jolting, squeezing, stamping, swaging, clamping, and cutting operations -- see Figure 2.

WITHOUT REGULATOR

Advance stroke	90 psi
Retract stroke	90 psi
Air consumed	156 cu.in./cycle

WITH REGULATOR

Advance stroke	90 psi
Retract stroke	20 psi
Air consumed	112 cu.in./cycle
Air saved	28%

FIGURE 2. HOW PRESSURE REGULATION SAVES ENERGY

Air Leaks

Leaks occur from defective hoses, couplings, fittings, valves, tubes, and actuators. Even leaks that cannot be detected audibly contribute to substantial energy losses. The cost of energy loss through misapplication and leakage in pneumatic systems is so appreciable that it often results in foundries purchasing unnecessary air compressor capacity. Unnecessary expenditures combined with wasted air can be curbed with effective energy management.

Example of loss in energy due to leaks:

- 1/16 inch diameter air leak uses about 2,520 kwh/year
- 1/8 inch diameter air leak uses about 10,100 kwh/year

DUST AND FUME COLLECTION

Dust collection equipment (baghouses, scrubbers, etc.) and its associated exhaust fans and miscellaneous accessories consume relatively large amounts of electricity.

Foundries generate a lot of dust and fumes in many phases of production. In order to satisfy the Environmental Protection Agency (EPA) and local air pollution control agencies, large volumes of air need to be exhausted. Fortunately, in California, there is no need for replacing exhaust air with heated make-up air, therefore, the energy expended is for pollution control equipment only.

The energy savings potential for dust of fume collection equipment is minimal providing the system is operated and maintained correctly. The following checklist should be implemented to minimize electrical power consumption.

1. Install well designed ventilation hoods to keep air volume to a minimum.

2. Keep pressure drops across filters within initial design parameters.

3. Develop and maintain strict preventative maintenance procedures.

4. Turn system off when not needed.

HEATING, VENTILATION, AND AIR CONDITIONING

The need for comfort heating, ventilation and air conditioning in California Foundries is practically nonexistent except for minor heating and air conditioning in offices and maybe some heating in pattern shops, laboratories, and the like.

Investment casting facilities generally have fairly large process air conditioning systems with stringent humidity requirements. Interior design conditions are usually 72°F dry bulb temperature and 45° relative humidity which requires both summer dehumidification and winter humidification.

Due to the many types of system variations and equipment applications in investment casting facilities it is impossible, and beyond the scope of this study, to recommend energy conservation measures in specific terms. Facilities with air conditioning systems larger than 20 tons (240,000 Btu/hr) should engage qualified professionals to optimize system performance.

The following list points out some areas where energy could be conserved either by retrofit, changes and/or modifications to existing systems:

- Add additional insulation to roofs, ceilings, or walls where practical.

- Install solar film on windows to cut cooling loads.
- Install weather stripping around windows and doors.
- Install higher efficiency lighting systems where possible.
- Reduce overall illumination levels.
- Recalibrate all controls.
- Lock thermostat to prevent resetting by unauthorized personnel.
- Install enthalpy controls to optimize use of outside air for natural cooling.
- Retest, balance, and adjust systems.
- Turn off air conditioning machinery during unoccupied hours.
- Optimize system startup times.
- Reduce outdoor air and system air volumes.
- Replace forced air heaters with infrared heaters.
- Insulate piping and ductwork in unconditioned spaces.
- Reclaim process exhaust energy and utilize it for space heating and absorption cooling.
- Install solar-assisted heat pumps.
- Replace constant volume air systems with variable volume type.
- Use proper water treatment to reduce fouling of heat transfer surfaces in chillers and heat exchangers.
- Maintain all equipment for peak efficiency.

PROCESS WATER

Some foundries utilize "once through" process cooling water systems for melt furnace and quenching operations.

Water recovery in the foundry is a valuable source of increasing operating economics, and can lend itself to energy recycling. Cooling for hydraulic presses, air compressors, melting furnaces, and quenching operations is generally accomplished with water. As much as 98% of otherwise wasted water can be recovered by installing a "closed loop" recirculating water system. The evaporative cooler, commonly referred to as a cooling tower is normally used for this purpose.

Other than conservation of natural resources, installation of a "closed loop" recirculation system will not conserve energy unless heat recovery is employed. In California, recovered heat can only be used for preheating domestic hot water, which would have to be required in fairly large amounts at the right time to make heat recovery economically feasible.

PLANT LIGHTING SYSTEMS

Foundries utilizing incandescent lighting systems can save significant amounts of energy by replacing with high pressure sodium units. For example: If a foundry replaced 365 - 1,000 watts incandescent units with 185 - 400-watt high pressure sodium units (HPS) the resulting decrease in electrical load would be 288 kilowatts with no significant change in lighting level. Assuming the lights burned 250 days per year, and 8 hours per day and the cost of electricity was 5 cents per KWH The energy cost savings would ammount to:

288 kW x 250 x 8 x 0.05 = $28,800 per year.

In addition to conserving electrical energy, further saving can be realized in replacement costs due to the longer life of the HPS System.

PART F

LONG TERM PROCESS CHANGES

CHARGE PREHEATING

Preheating of charge material is considered to be cost-effective, however, total use of energy may increase.

Overall energy reduction would be possible with gas preheating provided that waste heat is recovered for combustion air heating (see Figure 2).

The percent heat distribution in melting iron from 70°F temperature to 2,700°F is as follows:

Form	Temperature	Sp. heat Btu/lb./°F	Heat Content Btu/lb.	Percent Heat Required	Stage
Solid	70° F	0.130	10		
Solid	1,000° F	0.140	140	65%	Preheat
Solid	1,200° F	0.147	176		
Solid	2,300° F	0.161	370		
Liquid	2,300° F	0.214	492	22%	Melt
Liquid	2,600° F	0.209	543	13%	Superheat
Liquid	2,700° F	0.208	562		
				100%	

The percent heat required column indicates that major energy is used to preheat the metal.

The methodology used for comparing gas preheating versus all electric melting is as follows:

Heat required for preheating is expressed as:

Btu/lb. of metal = $(t_1 - t_2) \times$ specific heat

Where :

t_1 = final preheat temperature (1,000° F)

t_2 = initial cold temperature (70° F)

Specific heat of iron (0.140)

Therefore: Heat required to raise to 1,000° F is:

$(1{,}000 - 70) \times 0.140 = \underline{135.8 \text{ Btu/lb.}}$

Example

Find the cost differential, in dollars per ton, of metal preheated from 70° F to 1,000° F by utilization of gas or electricity.

(a) Electricity

- Energy introduced at coil based on 70% efficiency

$$\frac{(1{,}000 - 70) \times 0.140 \times 2{,}000}{70\%\ \text{eff.}} = 372{,}000\ \text{Btu}$$

- Energy required for auxiliaries

372,000 x 0.05	=	18,600 Btu
TOTAL	=	390,600 Btu

$$\text{Converted to KWH} = \frac{390{,}600}{3{,}412} = 114.5\ \text{KWH}$$

Assuming electricity cost \$0.05 per KWH = $5.725 per ton

(b) Gas

- Energy input based on 30% efficiency*

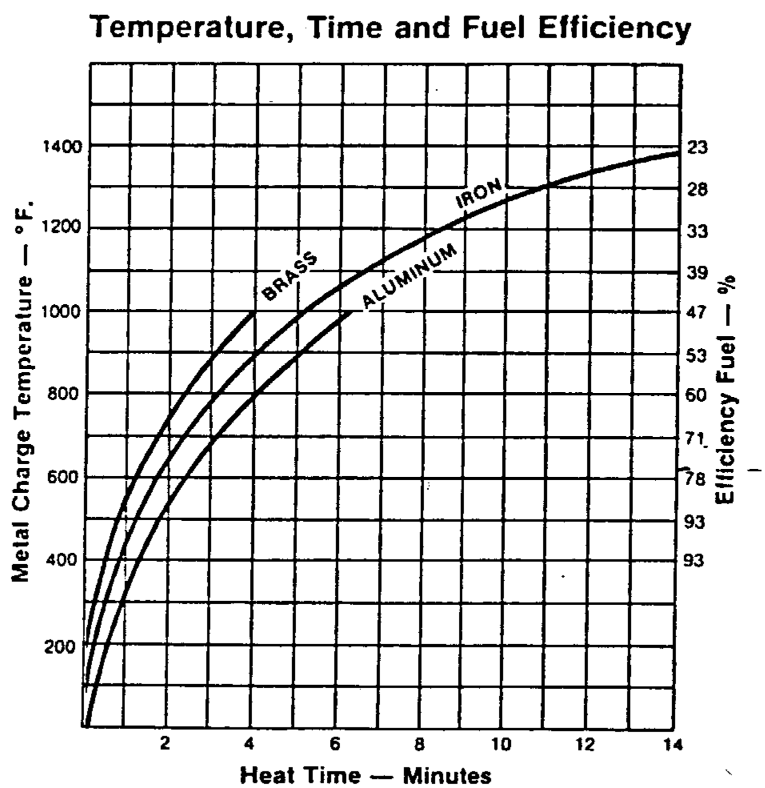
$$\frac{1{,}000 - 70 \times 0.140 \times 2{,}000}{30\%\ \text{eff.}} = 868{,}000\ \text{Btu}$$

Assuming gas costs \$0.30 per therm

$$\frac{868{,}000\ \text{Btu}}{100{,}000\ \text{Btu/therm}} \times .3 = \$\ 2.58\ \text{per ton}$$

From the above example it costs approximately double to preheat with electricity.

* See Figure No. 1.



High temperature, high velocity flames penetrate a thin evenly dispersed bed of scrap to achieve thorough, uniform heating at extremely rapid rate.

FIGURE 1

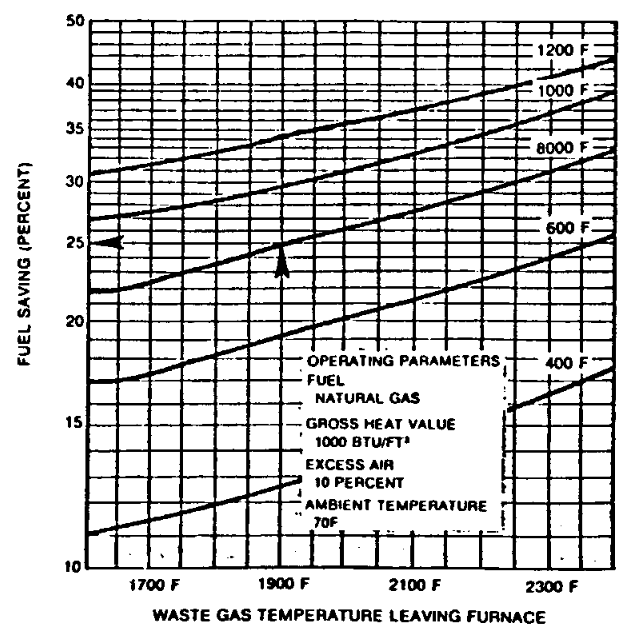


FIGURE 2

Fuel saved by preheating combustion air, as a function of flue gas and preheated air temperature. Example shows that with a waste gas temperature of 1,900 F and intake air preheated to 800 F in a recuperator, fuel savings achieved are 25%. Courtesy Thermal Transfer Corp., Monroeville, Pa.

COGENERATION

Cogeneration in simplistic terms is a process of "energy cascading" by utilization of waste heat from various foundry operations (i.e., heat treat furnaces, melt furnaces, etc.).

The first step (or top cycle) of a cogeneration system is the generation of electricity which is used for in-plant electrical base load or peaking load service, the electricity produced replaces, in part, that which is normally purchased from the utility company. The last step (bottom cycle) in the thermodynamic cycle is the use of waste steam for industrial processes and/or environmental conditioning (see Figure 1 below).

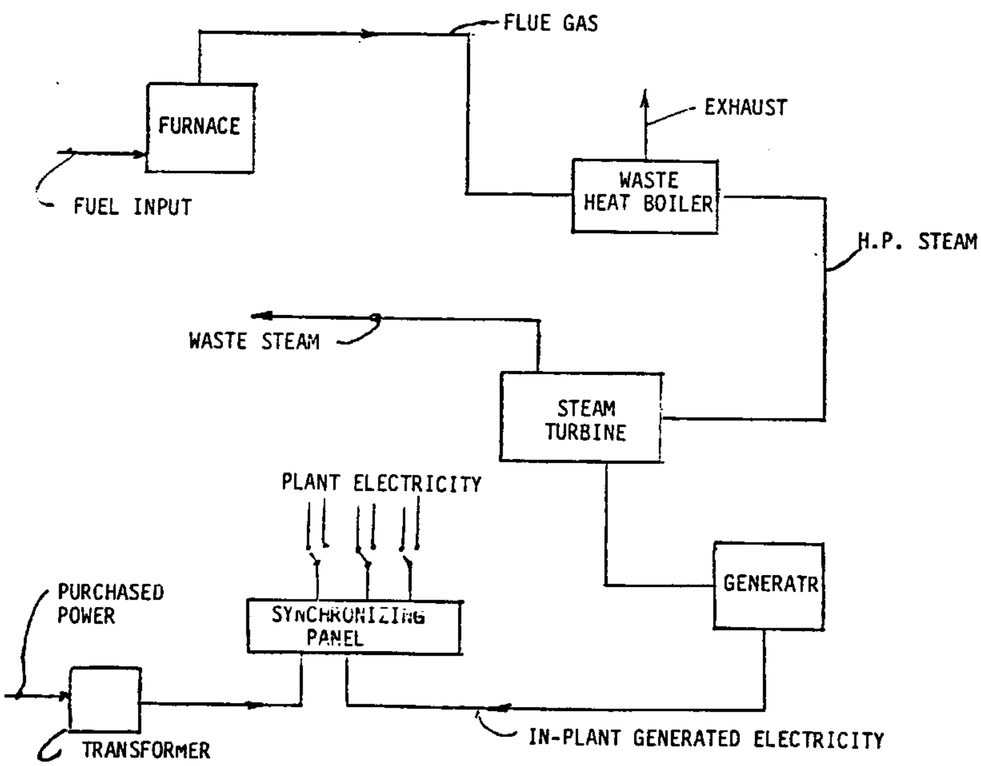


FIGURE 1. COGENERATION BLOCK DIAGRAM

Cogeneration in a typical foundry is an intermittent operation, electricity production is possible only when equipment that is developing waste heat is operational.

Referring to cogeneration block diagram, Figure 1, the following major equipment is required for onsite power generation:

- Waste heat recovery boiler; these are available in water tube or fire tube design.
- Steam turbine
- Electrical generator
- Automatic synchronization equipment

Generation of onsite power by utilization of plant waste heat is extremely costly to install and maintain. Also, generation of high pressure steam could possibly require a full-time Class "A" boiler operator.

The complexity and initial expense of cogeneration, when applied to the typical foundry, is not cost-effective at this time. A detailed and comprehensive analysis would be required to justify the use of onsite power generation in a foundry of suitable size to warrant such a system.

NOTE

Capital cost expenditures are in the order of magnitude of approximately $1,200 to $1,500 per kW installed.

PART G

MANAGEMENT ACTIONS

YIELD IMPROVEMENT PROGRAMS

Improvement in mold yield, to increase good castings relative to total poured metal, has a direct impact on energy usage by reduction of total melted metal required for a fixed weight of good castings.

Yield is made up of several parts comprising the effects of:

- Melt loss due to oxidation
- Slag
- Spill metal
- Pigged metal
- Pouring system, (gating, risers, excess casting weight)
- Scrap losses, grinding and machining losses

The typical foundry overall yield is 50% which results in required energy to melt double the finished casting weight. One percent yield improvement for 100-pound casting, from 50% to 51%, reduces metal melted by 4 pounds.

Melt Losses:	Occurs in all melting processes and ranges from 1-2% in electric furnaces to 7-10% in cupolas or higher in direct gas-fired furnaces. Selection of raw materials and redesign of melting unit and method changes can minimize the loss.
Slag:	Generated from impurities in the metal and oxidation, includes a percentage of pure metal, operating practices to restrict excess metal entrapment in the slag are necessary.
Spill:	Inaccurate pouring and bad transfer techniques results in metal melted that is not available for casting.
Pigged Metal:	Can amount to 1-2% of total metal melted. The correct measurement of ladle quantities is necessary in order to avoid skulls remaining after pouring. Correct sizing of ladles to prevent exceeding the workable pouring temperature range, before all the metal is utilized, will reduce pigging losses.

Pouring System: Ratio of poured metal to gross castings is the base yield fiqure. Improvements to runner systems, small risers or exothermic/insulators on the riser are required in an ongoing program to attain good yields.

Lightening of castings, if acceptable by the customer, will also reduce metal melting requirements and total energy used. The change may be in design of casting section thickness or closer tolerance to produce a casting with mold wall movement and "swell". The effect of weight reduction is shown in Figure 1.

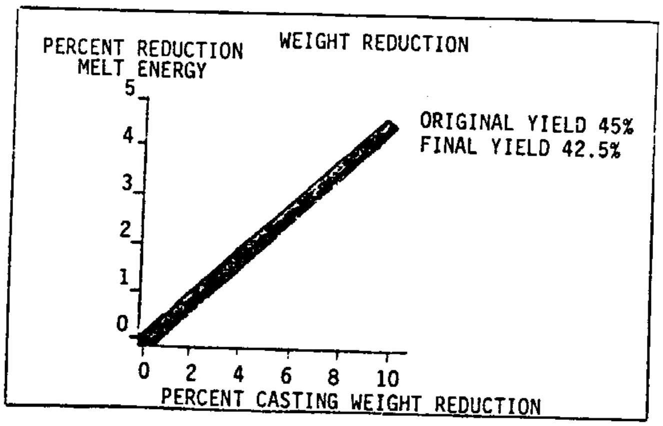


FIGURE 1. EFFECT ON MELT ENERGY OF REDUCING CASTING WEIGHT (Hayes Albion)

Scrap: Reduction of scrap is of utmost importance in all foundries for overall cost reduction and energy savings. Figure 2 shows the melt energy savings when scrap is reduced from 10 percent to zero. There is an approximate linear relationship of energy reduction to scrap reduction, ie; one percent scrap reduction saves one percent in energy input.

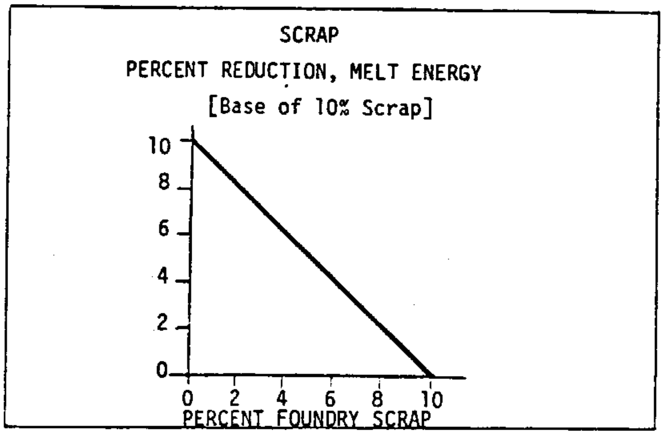


FIGURE 2. EFFECT ON MELT ENERGY BY REDUCING SCRAP

COMBINED EXAMPLE

	Sales Weight	Scrap	Yield	Melt Weight	Percent Energy Reduction
BASE	100%	8%	4.5%	241.5%	0
IMPROVE YIELD	100	8	$\boxed{50}$	217.4	8
REDUCE SCRAP	100	$\boxed{6}$	$\boxed{50}$	212.8	1.9
REDUCE SALES WT.	$\boxed{85}$	$\boxed{6}$	$\boxed{50}$	202.1	5.4
					$\boxed{15.3}$

FIGURE 3. EXAMPLE OF EFFECT ON MELT ENERGY WITH COMBINED IMPROVEMENTS IN YIELD, SCRAP AND CASTING WEIGHT

Grinding and Machinery: Losses due to machining away parts of the casting and grinding to remove ingate pads etc. must be minimized by design and careful positioning of ingates on the casting. Cooperation between customer's design engineer, on initial casting configuration, and the pattern maker is essential.

ESTABLISH ENERGY MANAGEMENT PROGRAM

For an energy management program to be fully effective foundry management should establish the position of "Director of Energy Conservation". The functions of this office would be:

- Establish the total energy cost per unit for each department or division.
- Perform in-plant inspections to identify energy conservation opportunities.
- Establish and maintain an on-going energy conservation program in each department.
- Establish in-house training program for department supervisors.
- Analyze future energy requirements.
- Assist in establishing plans and capital investment requirements for implementation of conservation programs.
- Provide personal contact between various utility companies.

A single person cannot physically handle all the above assignments; the Director of Energy Conservation must form a committee comprised of top level management people and other members of virtually all departments of the foundry such as melting, heat treating, mold and pouring, cleaning and finishing, and maintenance. The committee thus formed must coordinate a total energy management program to determine what is to be done to reduce the amount of energy used.

After determination of energy reduction measures the committee must follow through with the modifications and changes, to equipment and processes, necessary to accomplish the end results.

Implementation of a full scale energy management program coupled with comprehensive preventative maintenance procedures will, by refining proven and successful foundry management concepts, derive major energy and cost savings.

Efforts to improve foundry profitability by reducing equipment and process downtime, increasing yield through reducing casting weight, reducing scrap and improved scheduling will also pay off in conservation of energy and related cost savings.

Allout efforts to reduce energy consumption will significantly reduce the cost per ton of shipped casting, which will improve sales and profits. These challenges and opportunities are present in all foundries and should be carefully addressed by foundry management.

OPERATING PROCEDURES

Management approach must be to plan for operating with minimum energy usage. Improved scheduling in terms of when to run partial loads or reduce melting to fewer days but longer hours per day are very basic decisions.

It is not intended that all equipment operate 24 hours per day; careful scheduling can provide for metal to be melted up to pouring temperature at the time it is required, early melting will waste energy due to holding at temperature for long periods.

Changes in processes can be justified in energy savings, for example; shell or hot box core making conversion to cold box or no-bake methods.

General control of heating and high energy using equipment is necessary to see that it is only runnning when needed. Heat treat furnaces operated on a condensed schedule of several loads back to back will reduce the total energy required to initially heat up the mass of refractory, this is also covered in Section II.

Demand limiters for electric power and shifting the production or melting program to take advantage of off-peak power rates is also covered elsewhere.

Advantages of energy efficient conversions from direct fuel fired equipment to electricity may also be considered in terms of quality control refinements, improved operating conditions, with noise and exhaust requirements reduced. In nonferrous melting operations the cost advantage of reduced melt losses with electric melting offsets the added energy cost.

A checklist of practical energy conserving suggestions covering plant operations for management to investigate is included in the work book section, Volume II.

PART H

MAJOR PROCESS CHANGES

MELTING (GAS VERSUS ELECTRIC)

Foundries engaged in the planning of new melt facilities or contemplating major changes to existing facilities should analyze gas versus electric melting, particularly from the standpoint of fuel availability in the future. The following tables and graphs illustrate the differences in energy consumption and costs for various types of melting practices.

TABLE 1. COST OF ENERGY

Energy Source	Energy Cost per unit Delivered	Conversion Factor	Energy Cost per Therm (100,000 BTU)
Electricity	$ .04/KWH	3415 BTU/KWH	$ 1.172
Natural Gas	$2.50/1000 CF	1000 BTU/CF	$.250
Fuel Oil	$ .45/GAl	144,000 BTU/Gal.	$.312
Propane	$ .35/Gal	93,000 BTU/Gal.	$.376
Coke	$ .075/Lb.	12,690 BTU/Lb.	$.590
Coal (Bituminous)	$ .0175/Lb.	14.030 BTU/Lb.	$.124

Note: Costs of fuels have wide variations with regards to location and governmental control. The reader should research his particular situation with fuel costs. Moreover, availability of fuels rather than costs is emphasized in this paper.

Energy usage by alternate fuels is shown on the following Table 2.

TABLE 2. ENERGY REQUIREMENTS FOR MELTING AT 100% POWER UTILIZATION

ENERGY CONSUMPTION IN KWH PER TON					
METAL	TEMPERATURE (°F)	HEAT CONTENT KWH/TON	THEORETICAL OIL-FIRED	GAS AND COKE-FIRED	ELECTRIC (****)
Aluminum	1,400	295	1,406*-2,138**	N.U.	500
Copper	2,300	190	1,523*	N.U.	334
Gray Iron	2,750	340	N.U.	801***	500
Steel	3,000	363	N.U.	N.U.	606

References:
*Crucible Handbook, Crucible Institute.
**Stahl Specialty Company (Reverberatory Furnace).
***Cupola Handbook, AFS, 1965, P.292.
****Published Data by Induction and Arc Furnace Companies.

Example: Assume a requirement to operate six 2,000 lbs/hr aluminum melters with overall yearly utilization of 70 percent (no preheat).

Furnace	Melting Therms Per Ton/Yr	Holding Therms Per Ton/Yr	Therms/Ton Per Year	Cost/Year
Gas/Oil Reverb.	304,760	72,489	377,249	94,300/117,700
Gas/Oil Crucible	288,000	-	288,000	72,000
Coreless Induction	101,798	6,231	108,022	126,386
Channel Induction	71,744	3,232	74,976	87,722
Elect. Reverb.*1	88,965	1,100	90,065	105,376

Note: Above costs should be adjusted for particular situation and user energy rates. Also if 860°F preheat is utilized, gas/oil costs may be reduced approximately $24,500. Preheating for electric melt reduces costs approximately $13,000.

Energy only cost differences shows advantage for channel induction and gas crucibles, however, for cost justification analyses, other factors such as capital cost, maintenance, melt loss due to oxidation and general process variable should be taken into account on an individual basis.

MELTING (COKE VERSUS ELECTRIC)

Coke Fuel for Melting in Cupolas

The most efficient cupola system is a highly utilized, uninterrupted operation. This will present the best metal to coke ratio. Provided that the coke ratio does not change during melting, the only additional coke charges made are to compensate for variations in operation.

The length of campaign will also be reflected in bed coke usage, with ratios as low as 1:1 for short daily melting cycles, also delay in blast-on time, after igniting the coke bed, allows excessive burn-out and waste.

Distribution of energy from cupola coke is shown as follows:

	Percent
Heat in melted iron	40
Latent heat in stack gas	35
Sensible heat in stack gas	13
Other (slag, losses)	12
	100

Modifications to the conventional cupolas to recover much of the stack loss is feasible by use of the recuperative hot blast techniques, but a foundry may decide against this method because of excessive capital costs. Divided blast systems, where the tuyeres are located in two rows, separated by approximately 36 inches, is proven to increase top temperatures and reduce coke. Coke savings is also possible by enrichment of the blast air by 2.0 to 4.0 percent oxygen.

Injection of coke, breeze to reduce fuel cost plus use of Anthracite coke and shredded auto tires, as an energy and carbon pick up source, are other methods of savings, however in all cases the degree of savings is proportional to the capital cost and/or operating problems incurred. These energy reduction methods are all in use, but the total combination of savings is only available under experimental situations. Capital costs of over 1.0 million dollars is reported to be involved in upgrading cupolas for full maximization of energy savings.

Electric Furnace Melting

Furnaces for melting with electric power are available as follows:

- Direct Arc
- Coreless Induction
- Channel Type Induction
- Resistance Type - Reverberatory Furnaces

The efficiency of electric melting is highest where a full bath of metal at liquid stage is being heated. Ability to maintain temperature within close tolerance and melt on a continuous or intermittent basis is of major advantage in electric melting. Other applications of electric power usage, as applied to the melting of metal, is covered elsewhere in this study.

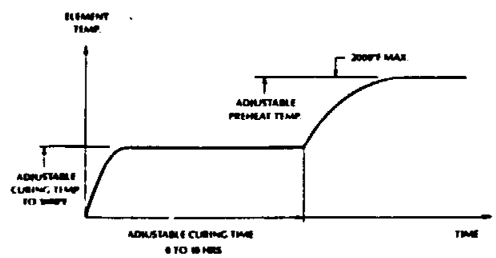
Efficiency of electric power usage, used in this analysis, does not include primary conversion of "in ground fuel" to electricity or transmission and transformer losses. Study considers only the energy as delivered to the foundry in usable state. Section II, Part D covers in-depth analyses of coke versus electric melting.

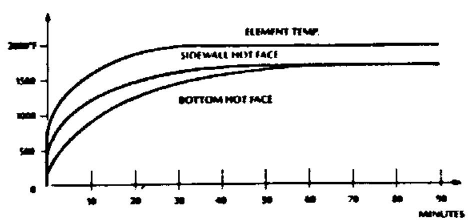
LADLE PREHEAT (GAS VERSUS ELECTRIC)

Electric ladle drying and preheating costs can be cut as much as 50%, depending on utility rates, by use of electric silicon carbide globar type elements utilized in conjunction with correctly designed ladle covers and controls.

The high thermal efficiency of electric ladle heaters, as compared to gas combustion devices in which a very large part of the available heat is wastefully vented to atmosphere, will afford maximum energy savings. As an added feature automatic programmed temperature control will provide close temperature control without overheating.

Figure 2 shows attainable curing and preheating cycles for 2,000-pound, 30-inch diameter ladle with a 65 kW heater.





Units available to suit ladle sizes are as follows:

kW	Ladle Size	Capacity-Pounds
25	17-1/2 - 21-1/2	500 - 1,000
40	21-1/2 - 27	1,000 - 2,000
65	27 - 34-1/2	2,000 - 4,000
100	34-1/2 - 43-1/2	4,000 - 8,000

SECTION II

INTRODUCTION

This section provides all necessary charts, graphs, tables, and mathematical formula for the development of energy savings in quantative form for:

- Electric power and cost savings relative to the melting of metal in all available types of furnaces. By utilizing hypothetical mathematical models it will be shown how to cut energy cost and/or consumption by improving power factors, installing demand limit controls, changing to "off-peak" melting and demand shifting.

- Gas energy reduction relative to melting, heat treating, and ladle preheating. By utilizing hypothetical mathematical models it will be shown how to reduce energy cost and/or consumption by improving combustion efficiencies, installation of ceramic fiber lining, installation of covers, and adding combustion air preheating.

- Reduction of coke usage in cupola melting by upgrading equipment such as adding hot blast via stack gas recuperation divided blast and oxygen enrichment. Also shown is the comparative energy usage for cupola versus electric melting.

PART A

ELECTRIC MELTING

GENERAL

As stated previously in Section 1 of this report, approximately 34% of the total energy input (all fuels) to a typical steel foundry is in the form of electricity, of this 34% approximately 60% is attributed to the melting of metal. This section deals with energy and cost savings in electric melting operations and covers the following areas.

- Furnace operation
- Energy usage
- Demand
- Demand control
- Off-peak melting
- Demand shifting
- Power factor correction

INPUT DATA

The required input data needed to analyze present melting operations, from the standpoint of energy consumption is:

- Electric utility bills for the past twelve months
- Kilowatt demand load profile
- Rate schedule for summer and winter "Time of Day" billing

The electric energy usage for 1979 calendar year is shown in Table 1. The kilowatt demand load profile covers a period of 48 hours and represents an electrical demand requirement for electric melting (See Figure 1). The load profile was developed from the kilowatt demand printout (See Table 2). From Table 2, it should be noted that the kilowatt demand for each five-minute interval for each 24-hour period is listed.

TABLE 1. ELECTRICAL POWER USAGE

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	376,800	2,291	.97	11,570	(638)	5,394	17,602	$ 16,964.00
FEBRUARY 1979	386,400	2,255	.98	10,757	(647)	5,318	16,722	16,075.00
MARCH 1979	367,200	2,279	.99	10,136	(648)	5,361	16,145	15,497.00
APRIL 1979	415,200	N/A	N/A	N/A	N/A	N/A	N/A	16,728.00
MAY 1979	376,800	2,266	.98	10,443	(548)	5,341	16,332	15,784.00
JUNE 1979	376,800	N/A	N/A	N/A	N/A	N/A	N/A	15,900.00
JULY 1979	228,000	2,281	.98	6,646	(450)	5,373	12,469	12,019.00
AUGUST 1979	384,000	2,262	.99	10,748	(476)	5,333	16,557	16,081.00
SEPTEMBER 1979	434,400	2,404	.99	12,117	(509)	5,634	18,260	17,751.00
OCTOBER 1979	432,000	2,443	.98	12,650	(505)	5,717	18,872	18,367.00
NOVEMBER 1979	468,000	2,500	.98	14,149	(521)	5,838	20,508	19,987.00
DECEMBER 1979	427,200	N/A	.99	N/A	(256)	N/A	15,029	14,772.00
TOTALS	4,672,800							$195,925.00

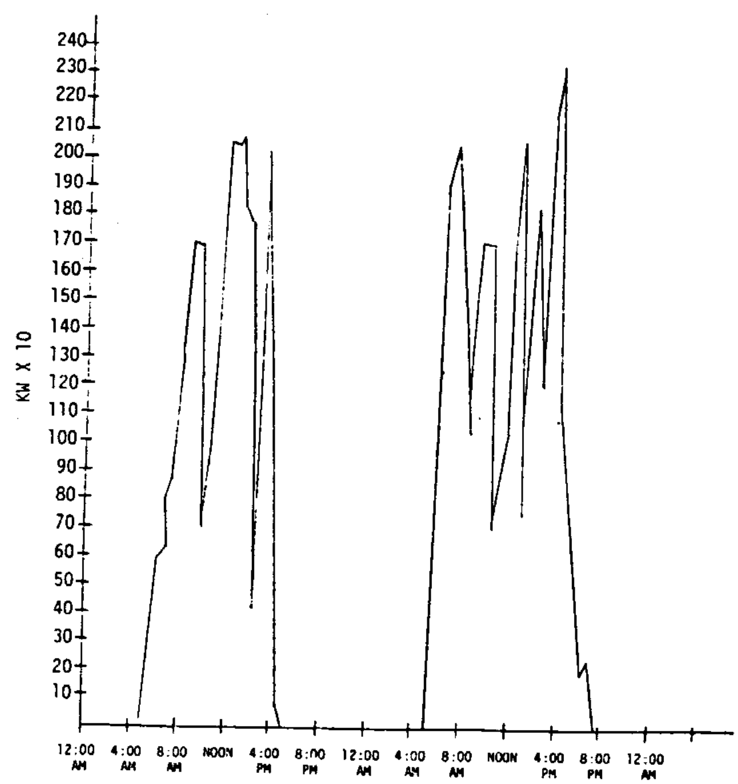


FIGURE 1. ELECTRICAL LOAD TABLES

TABLE 2. KILOWATT DEMAND PRINTOUT

Start
Time
12:05am
Column

INTVAL ENDING	MON 4-07	TUE 4-08	INTVAL ENDING	MON 4-07	TUE 4-08	INTVAL ENDING	MON 4-07	TUE 4-08	INTVAL ENDING	MON 4-07	TUE 4-08	INTVAL ENDING	MON 4-07	TUE 4-08	INTVAL ENDING	MON 4-07	TUE 4-08
05	0	0	405	0	0	805	1279	924	1205	2078	468	1605	842	902	2005	0	0
10	0	0	410	0	0	810	1231	943	1210	2112	460	1610	837	698	2010	0	0
15	0	0	415	0	0	815	1269	969	1215	2148	458	1615	782	532	2015	0	0
20	0	0	420	0	0	820	1326	972	1220	2148	540	1620	508	535	2020	0	0
25	0	0	425	0	0	825	1353	1034	1225	2102	628	1625	244	535	2025	0	0
30	0	0	430	0	0	830	1365	1380	1230	2037	736	1630	64	532	2030	0	0
35	0	0	435	0	0	835	1392	1567	1235	2023	1053	1635	28	424	2035	0	0
40	0	0	440	0	0	840	1500	1519	1240	1982	1401	1640	0	372	2040	0	0
45	0	0	445	0	0	845	1533	1533	1245	1951	1704	1645	0	336	2045	0	0
50	0	0	450	0	0	850	1579	1478	1250	2107	1756	1650	0	340	2050	0	0
55	0	0	455	0	0	855	1624	1396	1255	2088	1792	1655	0	345	2055	0	0
100	0	0	500	0	0	900	1704	1224	1300	2068	1819	1700	0	331	2100	0	0
105	0	0	505	48	88	905	1776	1027	1305	2059	1668	1705	0	326	2105	0	0
110	0	0	510	103	216	910	1843	1039	1310	2052	1514	1710	0	300	2110	0	0
115	0	0	515	158	338	915	1826	1058	1315	2037	1404	1715	0	259	2115	0	0
120	0	0	520	213	453	920	1680	1176	1320	1944	1485	1720	0	208	2120	0	0
125	0	0	525	266	566	925	1720	1257	1325	1910	1516	1725	0	170	2125	0	0
130	0	0	530	321	780	930	1694	1252	1330	1828	1552	1730	0	165	2130	0	0
135	0	0	535	336	1003	935	1452	1351	1335	1737	1579	1735	0	156	2135	0	0
140	0	0	540	340	1180	940	1224	1411	1340	1646	1567	1740	0	180	2140	0	0
145	0	0	545	345	1360	945	1068	1468	1345	1533	1579	1745	0	196	2145	0	0
150	0	0	550	360	1557	950	1056	1488	1350	1569	1516	1750	0	225	2150	0	0
155	0	0	555	412	1754	955	847	1536	1355	1694	1346	1755	0	232	2155	0	0
200	0	0	600	460	1867	1000	472	1591	1400	1725	1190	1800	0	237	2200	0	0
205	0	0	605	499	1884	1005	734	1716	1405	1557	1204	1805	0	232	2205	0	0
210	0	0	610	537	1927	1010	871	1960	1410	1372	1281	1810	0	208	2210	0	0
215	0	0	615	576	1965	1015	835	1982	1415	1231	1348	1815	0	216	2215	0	0
220	0	0	620	597	1992	1020	876	2095	1420	921	1449	1820	0	177	2220	0	0
225	0	0	625	588	2023	1025	888	2157	1425	561	1872	1825	0	144	2225	0	0
230	0	0	630	585	2037	1030	890	2157	1430	439	2104	1830	0	100	2230	0	0
235	0	0	635	580	2047	1035	859	2203	1435	573	2222	1835	0	62	2235	0	0
240	0	0	640	580	2064	1040	744	2064	1440	895	2320	1840	0	43	2240	0	0
245	0	0	645	580	2066	1045	765	2073	1445	1204	2388	1845	0	4	2245	0	0
250	0	0	650	583	2020	1050	806	2035	1450	1519	2438	1850	0	0	2250	0	0
255	0	0	655	607	1845	1055	895	2109	1455	1927	2313	1855	0	0	2255	0	0
300	0	0	700	619	1689	1100	1092	2222	1500	2013	2308	1900	0	0	2300	0	0
305	0	0	705	655	1695	1105	1262	2205	1505	2068	2268	1905	0	0	2305	0	0
310	0	0	710	691	1665	1110	1440	2196	1510	1922	2155	1910	0	0	2310	0	0
315	0	0	715	751	1516	1115	1550	2215	1515	1807	1869	1915	0	0	2315	0	0
320	0	0	720	818	1416	1120	1677	2205	1520	1754	1596	1920	0	0	2320	0	0
325	0	0	725	871	1454	1125	1778	2025	1525	1608	1324	1925	0	0	2325	0	0
330	0	0	730	914	1468	1130	1792	1749	1530	1536	1204	1930	0	0	2330	0	0
335	0	0	735	969	1322	1135	1824	1466	1535	1341	1140	1935	0	0	2335	0	0
340	0	0	740	1034	1176	1140	1876	1212	1540	1120	1135	1940	0	0	2340	0	0
345	0	0	745	1084	1166	1145	1980	928	1545	907	1272	1945	0	0	2345	0	0
350	0	0	750	1108	1159	1150	1951	674	1550	868	1219	1950	0	0	2350	0	0
355	0	0	755	1152	1113	1155	1997	542	1555	837	1173	1955	0	0	2355	0	0
400	0	0	800	1233	931	1200	2042	499	1600	876	1027	2000	0	0	2400	0	0

Kilowatt
Demand
Column

Finish
Time
12:00pm
Column

LOAD PROFILE DEVELOPMENT

Foundries with a separate electrical service to their melting furnaces can develop their own in-house kilowatt load profile in the following manner. Prepare a chart, using graph paper with one-tenth of an inch/to one inch divisions, recording time along abscissa axis and kilowatt demand along ordinate axis. Along the abscissa axis set out the "time of day" billing hours. Setting up the graph in this manner will indicate if the high kilowatt demands are occurring during the "on peak" hours (See Figure 2). From the kilowatt demand printout, record the thirty minute kilowatt demands for chosen time periods. When all 30-minute kilowatt demands have been recorded, connect all points to obtain profile of load. The procedure for developing a winter kilowatt load profile is the same as "summer", but the "time of day" billing hours change (See Figure 3).

Foundries that are not provided with a kilowatt demand printout for their electric melting operation or have only one electrical service for both melting and general plant service will need to install submetering of the service feeders.

Using a three-phase tap-type recording ammeter and a clip on type power factor meter the necessary data can be obtained to find the kilowatt demand.

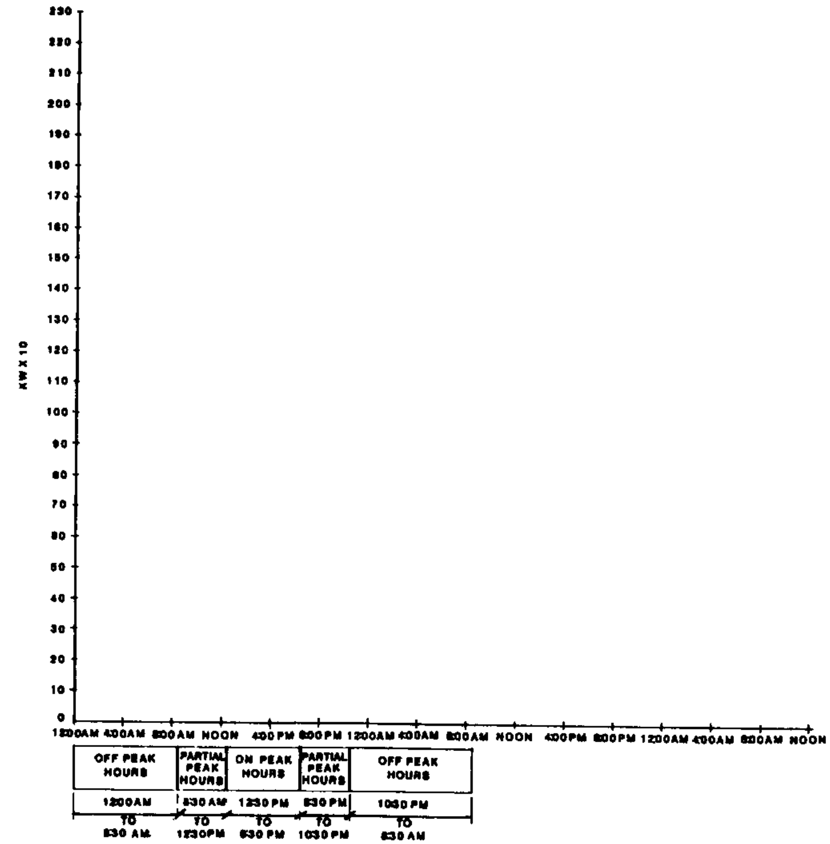
Example

If the ammeter recorded 400 amperes with a 0.80 power factor the kilowatts would be as follows:

$$\frac{I \times E \times 1.73 \times PF}{1000}$$

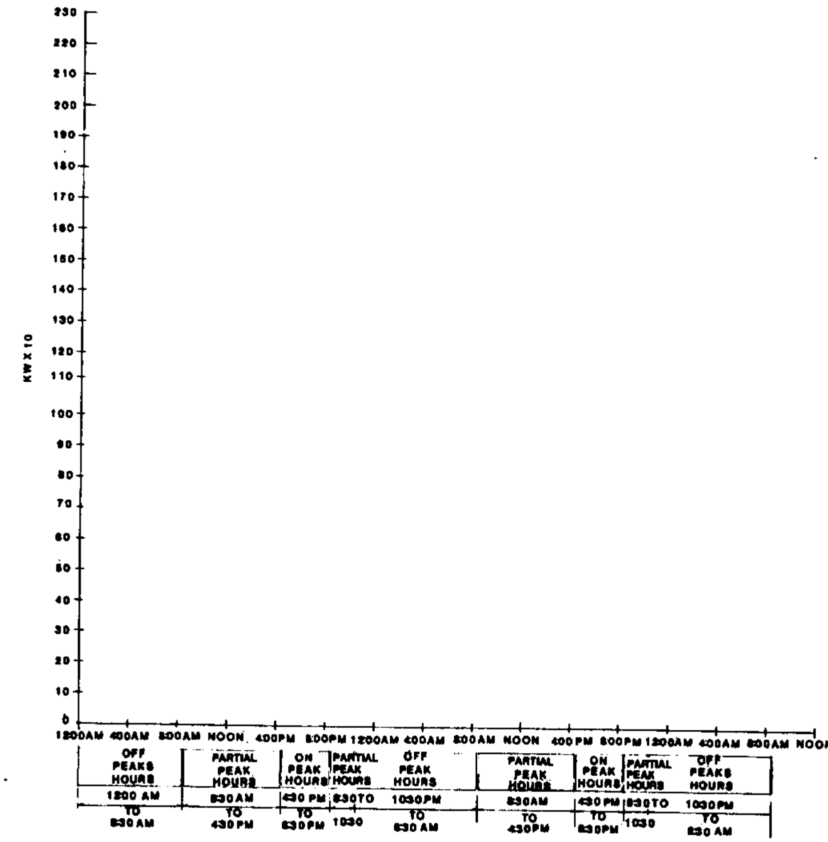
$$\frac{400 \times 480 \times 1.73 \times .80}{1000} = 265 \text{ kilowatts}$$

From the above reading the kilowatt load profile can be developed.



KILOWATT DEMAND PROFILE (SUMMER)

Figure 2



KILOWATT DEMAND LOAD PROFILE (WINTER)

Figure 3

OFF-PEAK METAL MELTING

Utilizing "off-peak" hours for metal melting, substantial cost savings can be realized by lowering the demand and energy charges.

Figure 4 illustrates a total demand load of 2,300 kilowatts, of this amount approximately 59% or 1,357 kW is attributed to melting of metal, the remainder is base plant electrical load.

The following sample calculations illustrate the electrical cost for demand, energy and fuel adjustment charges for melting in on-peak and off-peak hours.

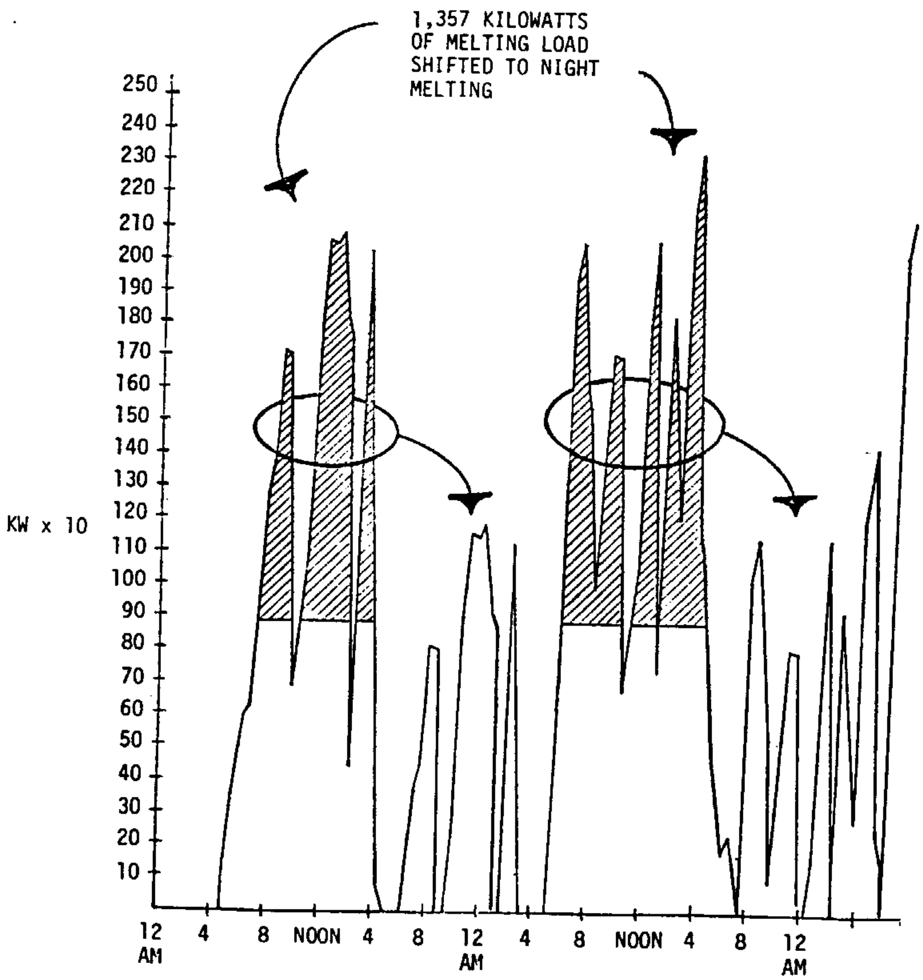


FIGURE 4.

SAMPLE CALCULATION (On-Peak Period)

Demand Charges:

On-peak per kilowatt of maximum demand	
Total on-peak 1369 kW at $2.50	$ 3,422
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 1363 kW at $0.30	$ 408
Plus off-peak, per kilowatt of maximum demand	
Total off-peak 1358 kW no charge	$ 0
Subtotal	$ 3,830

Energy Charges:

On-peak, per kilowatt hour: 12:30pm to 6:30pm 4-5hrs/day	
Total kilowatt hours 98,571 x ¢0.022/kwh	$ 2,168
Partial peak, per kilowatt hour: 8:30am to 12:30pm and 6:30pm to 10:30pm 8hrs/day	
Total kilowatt hours 145,135 x ¢0.019/kWh	$ 2,757
Off-peak, per kilowatt hour: 10:30pm to 8:30am 10hrs/day	
Total kilowatt hours 183,875 x ¢0.010/kwh	$ 1,839
Subtotal	$ 6,764

Fuel Adjustment Charges:

Total kilowatt hours = 427,582 x 0.04063	$ 17,372
Grand total for (demand, energy and fuel adjustment charges)	$ 27,966

Above calculations are based on normal day shift working hours and summer "time of day" billing rates for a 30-day period. Figures are abstracted from power company metered print-outs.

Off-Peak Melting

Demand Charges:

"On-peak" per kilowatt of maximum demand	
Total on-peak none at $2.50	$ 0
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak none at $0.30	$ 0
Plus "off-peak" per kilowatt of maximum demand	
Total off-peak 1239 at no charge	$ 0
Subtotal	$ 0

Energy Charge:

"On-peak", per kilowatt hour: 12:30pm to 6:30pm 6hrs/day	
Total kilowatt hours none x ¢0.022/kwh	$ 0
"Partial peak" kilowatt hours: 8:30am to 12:30pm and 6:30pm to 10:30pm 8hrs/day	
Total kilowatt hours none x ¢0.019/kwh	$ 0
"Off-peak" kilowatt hours: 10:30pm to 8:30am 10hrs/day	
Total kilowatt hours 427,582 x ¢0.010/kwh	$ 4,275
Subtotal	$ 4,275

Fuel Adjustment Charges:

Total kilowatt hours = 427,581 x ¢0.04063	$17,372
Grand total for (demand, energy and fuel adjustment charges)	$21,647

Potential cost savings by shifting to off-peak melting would be $27,966 - $21,647 = $6,319 or 22.5% savings for the 30-day period.

DEMAND SHIFTING AND DEMAND CONTROL

If night melting is not possible, demand shifting and control will permit metal melting during normal "on-peak" day time hours and still save substantial costs. Demand shifting will extend the melting period; this permits the sequential operation of the furnaces, thereby reducing the peak maximum demand.

With uncontrolled operation, large kilowatt demands are developed which produces low demand factors and low efficiency of power usage. Figure 5 is representative of an uncontrolled operation of power input to several furnaces. Figure 6, indicates how the kilowatt demand can be reduced by extending the hours of melting operations, the demand limit is set at 1,700 kilowatts. The sample calculations illustrate the potential cost savings if demand shifting and control is utilized. To insure complete control of a set maximum demand, an automatic demand controller should be installed, this controller automatically regulates or limits operation in order to prevent a set maximum demand from being exceeded. With the monitored information, the controller can calculate when an overload of the set demand will occur. The controller will delay any shed action to allow time for loads to shed normally. When it is determined that it will be necessary to shed one or more loads to keep from exceeding the set kilowatt demand, the controller will shed the necessary load. This means that shedding will occur only once during a demand interval and maximum use of available power will be realized.

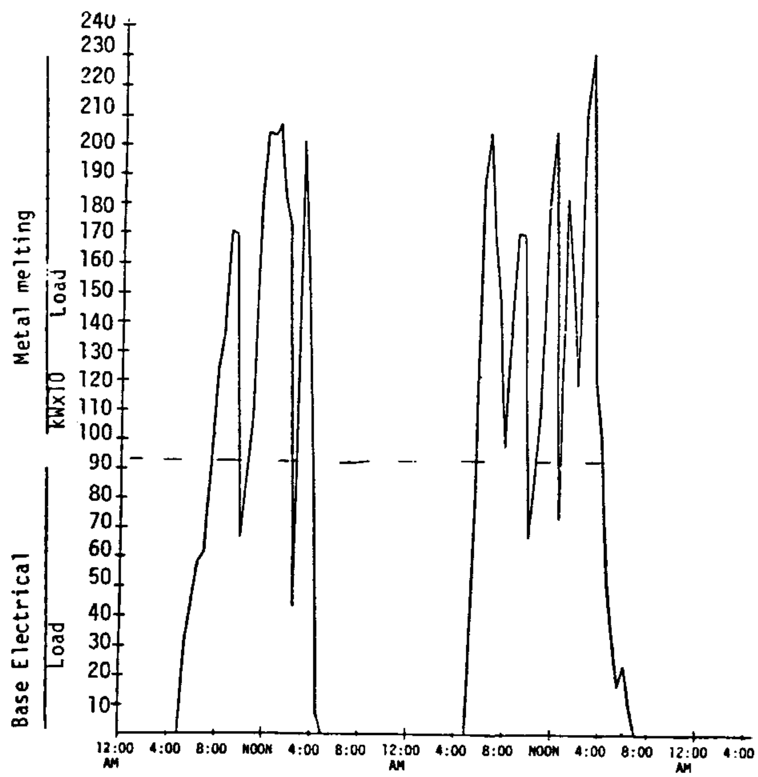


FIGURE 5. ELECTRICAL LOAD PROFILE (UNCONTROLLED)

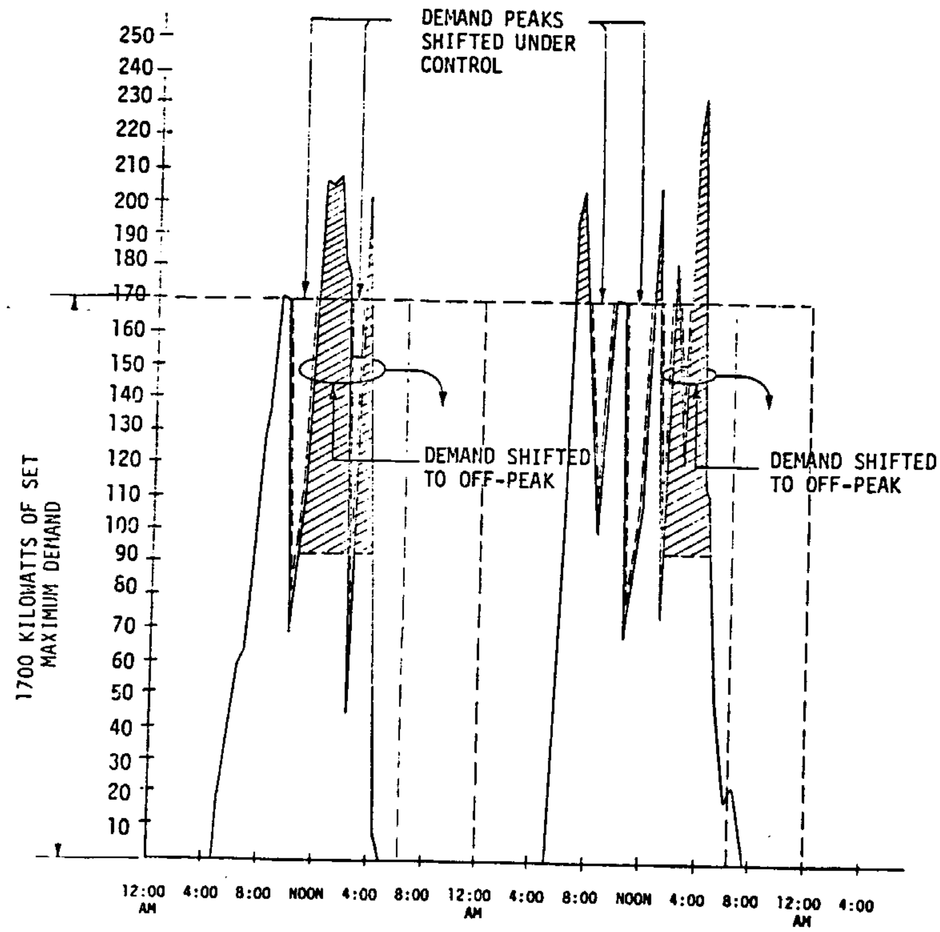


FIGURE 6. ELECTRICAL LOAD PROFILE (CONTROLLED)

Sample Calculations (Uncontrolled Operation)

Demand Charges:

"On peak" per kilowatt of maximum demand		
Total on peak 1,033 kw at $2.50	$	2,507
Plus partial peak per kilowatt of maximum demand		
Total partial peak 998 kw at $0.30	$	299
Plus "off-peak" per kilowatt of maximum demand		
Total off-peak 994 kw no charge	$	0
Subtotal	$	2,806

Energy Charge:

"On peak", per kilowatt hour: 12:30pm to 6:30pm 6 hrs/day		
Total kilowatt hours 98,571 x ¢0.022/kwh	$	2,168
"Partial peak" kilowatt hour: 8:30am to 12:30pm and 6:30pm to 10:30pm 8hrs/day		
Total kilowatt hours 145,135 x ¢0.019/kwh	$	2,757
"Off-peak" per kilowatt hour: 10:30pm to 8:30am 10hrs/day		
Total kilowatt hours 183,875 x ¢0.010/kwh	$	1,839
Subtotal	$	6,764

Fuel Adjustment Charges:

Total kilowatt hours = 427,582 x 0.04063	$	17,372
Grand total for (demand, energy and fuel adjustment charges)	$	26,942

Sample Calculations (Controlled Operation)

Demand Charges:

"On peak" per kilowatt of maximum demand		
Total on peak none kw at $2.50	$	0
Plus partial peak per kilowatt of maximum demand		
Total partial peak 998 kw at $0.30	$	299
Plus "off-peak" per kilowatt of maximum demand		
Total off-peak 994 kw no charge	$	0
Subtotal	$	299

Energy Charge:

"On peak", per kilowatt hour: 12:30pm to 6:30pm 6 hrs/day		
Total kilowatt hours none x ¢0.022/kwh	$	0
"Partial peak" kilowatt hour: 8:30am to 12:30pm and 6:30pm to 10:30pm 8hrs/day		
Total kilowatt hours 145,135 x ¢0.019/kwh	$	2,757
"Off-peak" per kilowatt hour: 10:30pm to 8:30am 10hrs/day		
Total kilowatt hours 282,446 x ¢0.010/kwh	$	2,824
Subtotal	$	5,581

Fuel Adjustment Charges:

Total kilowatt hours = 427,582 x 0.04063	$	17,372
Grand total for (demand, energy and fuel adjustment charges)	$	23,252

DEMAND CONTROL

With a power demand controller installed on the power system supply to the furnaces, maximum kilowatt demand can be controlled.

The controller automatically regulates or limits operation in order to prevent a set maximum demand from being exceeded. The controller predetermines the demand limit and the demand interval. The sequence of operation is similar to that described under "load shifting and control".

Figure 7, illustrates the new load profile with demand set at 1,700 kW. Cost savings are the same as those computed under "Load Shifting and Control."

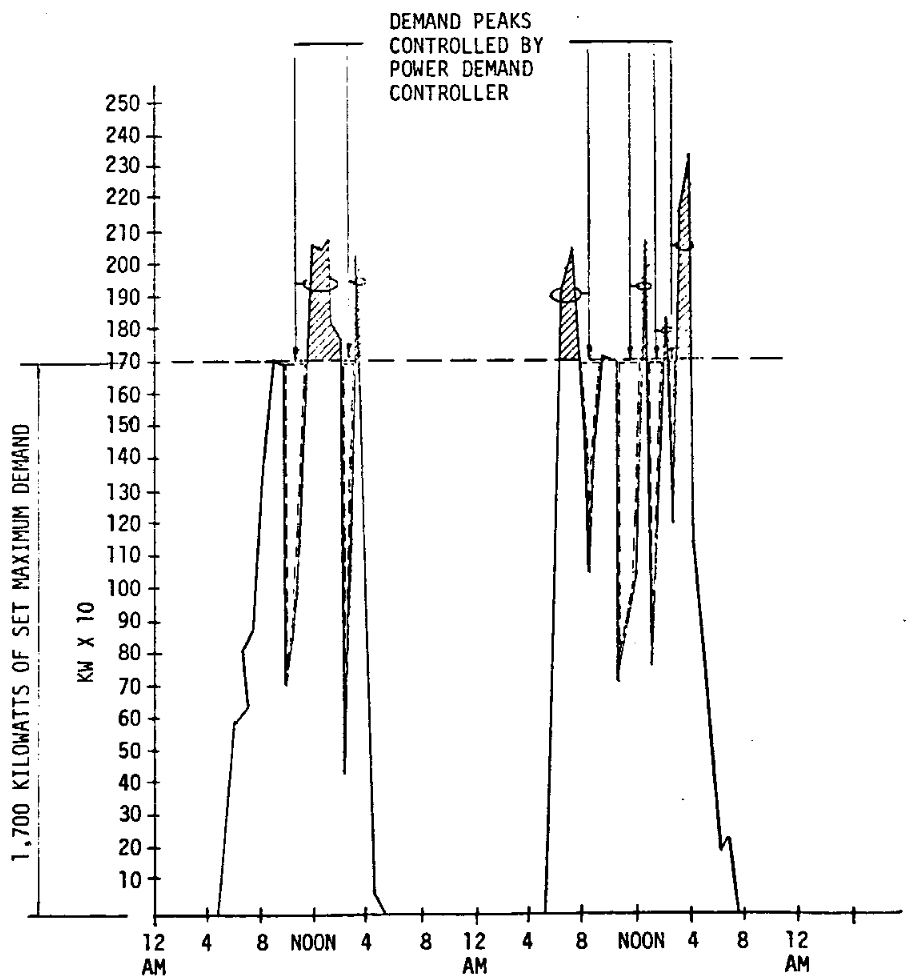


FIGURE 7. ELECTRIC LOAD PROFILE (DEMAND CONTROL)

POWER FACTOR CORRECTION

The electrical efficiency of the coreless induction furnace is approximately 76-81 percent with a power factor of approximately 90-98 percent, the channel furnace is approximately 94-95 percent with a power factor of 94-98 percent. With these high power factors designed into the furnaces, no additional correction is necessary.

On the other hand arc furnaces have an approximate power factor of 70%, if capacitors are not installed on furnace transformers. It should be noted that power factor improvement will not save in-plant energy or reduce the customer's power bill, but will save energy at the utility company power plant thereby reducing the nation's dependence on oil.

IMPROVED FURNACE DESIGN

Induction Furnaces

Improved profile of the power coil reduces the magnetic flux lines penetrating through the outside corners, which in turn minimizes eddy current loss, thereby improving furnace efficiency.

Use of castable backup refractory will eliminate the need for cooling coils and save the energy that would otherwise enter into the cooling water. The efficiency of the furnace can be increased as much as 10% with these improvements. A foundry producing 25 tons a day can save approximately $17,000 per year. Using representative figures for this example the savings compute as follows:

Total energy required to melt 25 tons of metal per day =

$$\frac{25 \times 500 \text{ kwh/ton}}{0.76\% \text{ efficiency}} = 16{,}500 \text{ kwh}$$

10% improvement = 16,500 x 0.10 = 1,650 kwh savings/day

Savings/year at 240 days = 1,650 x 240 = 400,000 kwh

Average power at $0.0427/kwh

400,000 x $0.0427 = $17,000 savings/year

Arc Furnaces

The installation of water-cooling on the sidewalls of the furnace will reduce downtime necessary for refractory replacement. With installation of water-cooled blocks there is about 10% increase in total furnace productivity; other benefits are:

- 80% decrease in side wall brick consumption
- Reduction of power "on-time" by 13%
- 3% energy savings
- 8% reduction in electrode consumption

The installation of solid-state furnace controls will automatically position the electrodes within the furnace. The control maintains more accurately the arc setpoint which give constant power input and longer refractory life. The resistance sensing compensates for reactance to allow more sensitive action to the arc resistance. With a constant arc stability it provides for a higher through-put, with a higher input power usage. The energy savings that can be realized are approximately 10 percent.

Electric Glo-Bar Reverberatory Melting Furnace (ERMF)

Installation of furnace covers over the charging and dipout wells and the bath will save energy.

Sample Calculation

Potential energy savings in covering a four-square-foot opening based on radiation losses of 20,000 Btu's/SF/hr for covered furnaces.

Four SF Area

Losses without cover = (4 x 20,000)	=	80,000 Btu/hr
Losses with cover = (4 x 500)	=	2,000 Btu/hr
Net reduction	=	78,000 Btu/hr
Losses per 10-hr day = (78,000 x 10)	=	780,000 Btu
kwh saved (780,000 ÷ 3412)	=	228 kwh
Annual savings (240 days x 228 x $0.042)	=	$2,298.00

Graphite Rod Holding Furnace

As the graphite rod holding furnace is not a primary melting furnace, this furnace will not be addressed with regards to lost energy. The efficiency and utilization of energy input for metal holding is high. The power factor is maintained at near unity with this type of unit.

SUMMARY

POTENTIAL ANNUAL COST SAVINGS
FOR ELECTIRCAL ENERGY AND DEMAND[1/]

ITEM	PRESENT CONDITIONS		POTENTIAL CONDITIONS		POTENTIAL ANNUAL COST SAVINGS $
	ENERGY CONSUMED KWH	ENERGY AND DEMAND COST $	ENERGY CONSUMED KWH	ENERGY AND DEMAND COST $	
Off-Peak Melting	5,130,984	335,592	5,130,984	259,764	75,828
Demand Shifting and Demand Control	5,130,984	323,304	5,130,984	279,024	44,280
Demand Control Only	5,130,984	335,592	5,130,984	323,304	12,288
Furnace Covers	56,272	2,363	1,406	65	2,298
Improved Furnace Design	3,960,000	169,092	3,564,000	152,182	17,000

1/ Developed from sample calculations shown previously in this text.

1. Potential annual cost savings are based on 240 operating days per year.
2. Energy consumed per year is based on furnace loads only. Does not include plant base loads.
3. Average energy cost of $0.06 per kwh based on 1980 rate schedules should be used in place of $0.04 used in examples.
4. Potential energy savings shown are not all accumulative.

PART B

NATURAL GAS MELTING

GENERAL DESCRIPTION

This section deals with energy savings in gas melting operations:

Formulas, calculations, and graphs have been simplified within the Scope of the Project from the normally complex task of calculating heat transfers to reflect constant conditions during the process.

To investigate any process in depth, it is essential to establish parameters, calculate the data and plot results on a continuous basis to establish the limits of the operation and equipment, and identify any trends.

The work sheet lists the expected parameters for furnaces, burner and ancillary equipment and operational data to complete a "one shot" energy audit. This constitutes a base for any future improvements. A tape measure, thermometer, flue gas analyzer and flowmeters will be the tools needed.

GAS FURNACE DATA INPUT

Metal type: Aluminum   Annual tons 1,500

Pouring or tap temperature 1380 °F

1/ Heat content Btu/lb 497   Shifts/day One

Melting period hrs. 8   Holding period hrs. 16

Method of Melting	Crucible	Reverb
Metal melted/hr. lbs.	2,000	2,000
Burner rating Btu/hr	3.6×10^6	4.85×10^6
Total gas usage/hr CFH	3,600	4,850
Capacity of furnace lbs.	2,000	5,000
Crucible diameter	36"	-
Area of metal radiation sq. ft.	4.0	4.0
Area of refractory wall:		
Below metal sq. ft.	110	40
Above metal sq. ft.	-	40
Thickness of wall ins.	6	6
Door open area or dip well sq. ft.	-	-
Mean temperature of walls °F	-	-
Outer temperature of wall T_1	100°F	100°F
Inner temperature of walls T_2	3,000°F	2,000°F
Present refractory K value	N/A	6
Proposed refractory K value	-	-
Rs value for refractory	-	-
CO_2 flue gas reading	5% CO_2	
Combustion air cfm	N/A	N/A
Combustion air wg	N/A	N/A
Flue gas temperature	1,150°F	1,600°F
Ambient temperature °F	-	-
Time of day used	-	-
Days/year used	240	240
Energy cost/therm $	$0.30	

1/ See Figure 1 for input data.

GRAPHS, TABLES AND CHARTS

The following graphs, tables and charts illustrated here are to be utilized for performing sample calculations for anticipated energy reduction measures.

Heat Content of Metals

The following graph (Figure No. 1) shows the heat content of numerous metals and alloys for various temperature ranges:

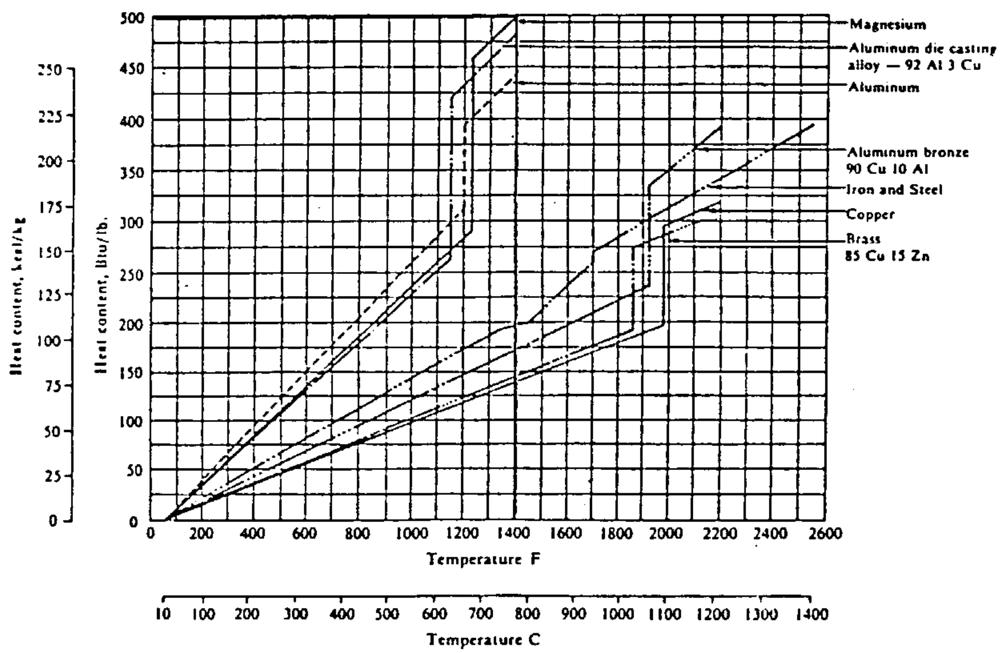


FIGURE 1. NORTH AMERICAN HANDBOOK

Example of use: With a 1400°F metal temperature, the heat content of aluminum die casting alloy is approximately 500 BTU/lb.

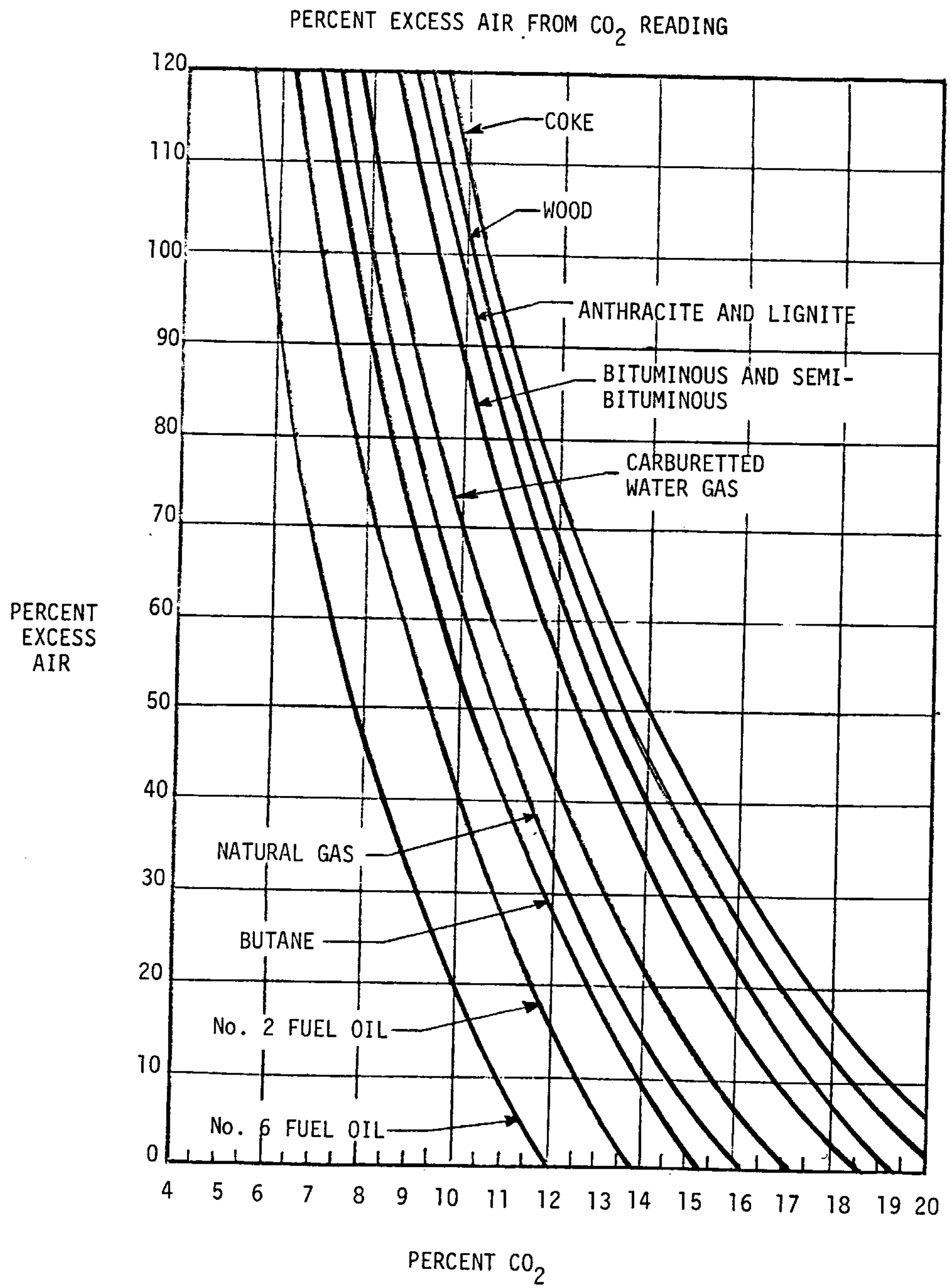


Figure No. 2

Source: North American Combustion Handbook.

Example of Use: A combustion analysis shows 6% CO_2 content of the flue gas, with natural gas burning equipment the excess air is approximately 90%.

PERCENT AVAILABLE HEAT

From North American Combustion Handbook

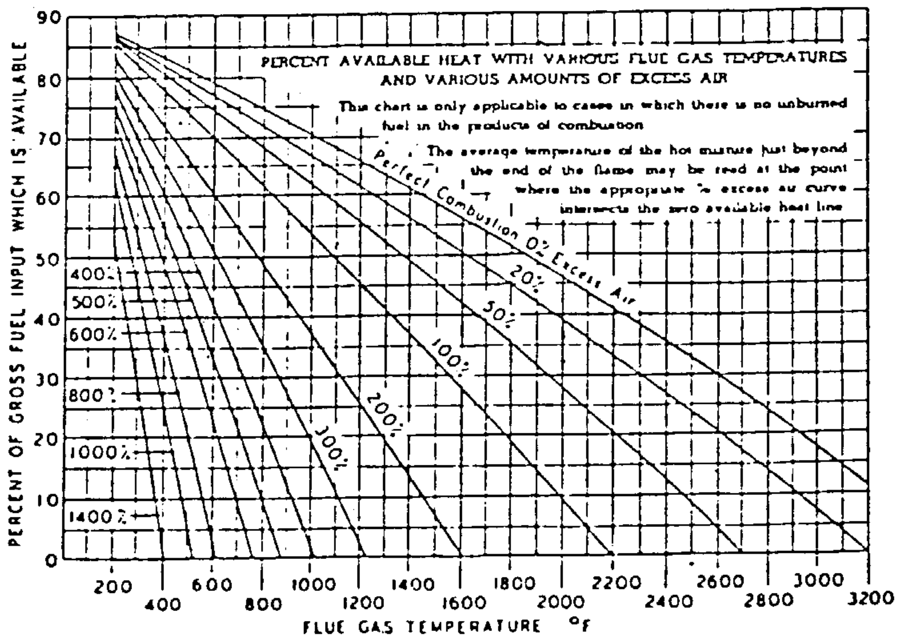


Figure No. 3

Example of use: With a flue gas temperature of 1100°F and an excess air requirement of 90%, the amount of heat available for metal melting (including heat lost by radiation) is approximatly 52%.

Typical thermal properties of refractory and insulating concretes.

Aggregate.	Fired density, lb. per cub. ft.	Heat capacity, B.t.u. per (cub. ft.) (deg. F.)	Thermal conductivity, B.t.u. per (hr./sq. ft.) (deg. F. per in.)	Thermal diffusivity, (sq. ft. per hr.)
Vermiculite ..	35	9	1.2	0.011
Diatomite	55	14	1.7	0.010
Crushed H.T. insulating brick ..	85	21	3.2	0.013
Expanded clay ..	90	22	3.5	0.013
Crushed firebrick ..	115	29	6	0.017
Molochite ..	120	31	8	0.021
Sillimanite	135	33	10	0.025
Carborundum ..	145	40	50	0.103
Calcined bauxite ..	160	45	12	0.022
Magnesite	160	45	20	0.037
Chrome-magnesite ..	165	37	8	0.018
Fused magnesia ..	170	50	24	0.04
Fused alumina ..	175	52	16	0.026
Bubble alumina ..	95	22	6	0.023

TABLE - 1

Example of use: Read "K" (thermal conductivity) for type of lining in use.

PHYSICAL PROPERTIES*

	2100	2400	2600	2800	3000
Maximum Recommended Use Temperature	2100°F (1150°C)	2400°F (1315°C)	2600°F (1425°C)	2800°F (1540°C)	3000°F (1650°C)
Density (PCF)	12-15	18-22	18-22	18-22	18-22
Thermal Conductivity - k (BTU - In./S.F. - °F - Hr.)					
Mean Temperature °F: 600°F	0.26	0.29	Same k values for these compositions.		
800°F	0.36	0.35			
1000°F	0.48	0.41			
1200°F	0.62	0.48			
1400°F	0.77	0.57			
1600°F	0.93	0.67			
1800°F	1.08	0.79	"k" measurements made at Refractories Research Center, Ohio State University.		
2000°F	1.24	0.93			
2200°F	-	1.10			
2400°F	-	1.30			

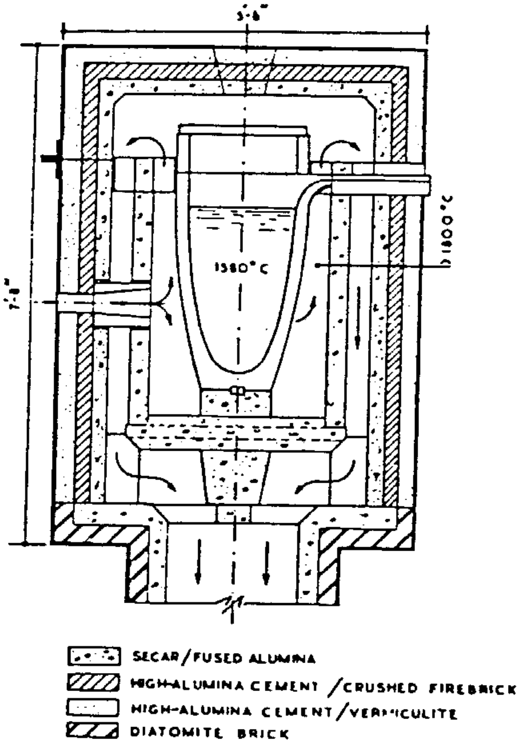
Ref. Industrial Insulations, Inc.

TABLE - 2

Example of use:

Determine mean temperature from formula; $\frac{t_1 - t_2}{2}$ = Mean wall temp.

Read "K" thermal conductivity under maximum recommended use temperature.



Composite refractory- and insulating-
concrete lining of a propane-fired furnace

Figure No. 6

Example of K values for above material, refer to Fig. 4

Fused alumina,	K = 16
Crushed Firebrick,	K = 6
Vermiculite,	K = 1.2
Diatomite Brick,	K = 1.7

HEAT STORAGE AND LOSSES BTU/SQ. FT.

WALL THICKNESS	TYPE REFRACTORY	HOT FACE TEMPERATURE °F					
		1,200		1,600		2,000	
		H. ST.	H.L.	H. ST.	H.L.	H. ST.	H.L.
9"	Composite 2,000° insulation and firebrick	13,700	285	19,200	437	24,800	615
13-1/2"	Composite 2,000° insulation and firebrick	22,300	335	31,400	514	40,600	718
22-1/2"	Composite 2,000° insulation and firebrick	43,200	182	61,000	281	79,200	392
6"	Ceramic fiber	842	208	1,170	432	1,490	672

H. ST. - Heat Stored
H. L. - Heat Lost. BTU/Hr.

TABLE - 3

PREHEATING OF COMBUSTION AIR

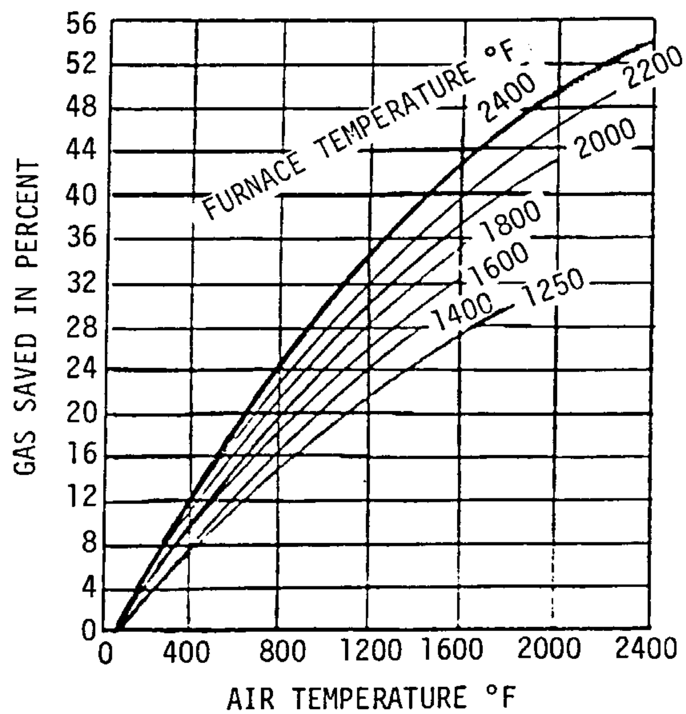


Figure No. 8

Example of use: Read gas saved in percent against furnace temperature curve for combustion air temperature obtained.

At 1600°F furnace temperature, and 1200°F air temperature, the gas saved is approx. 26 percent.

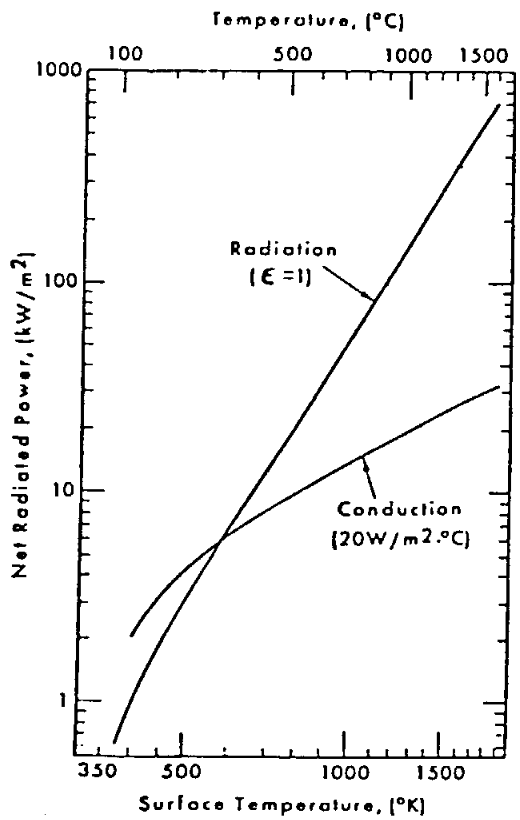


Figure No. 9

Example of use: Read net radiation (kw/m^2) against surface temperature and radiation curve.

> e.g. at 800°C, radiated power is approx. 100 kw/m^2.
> Where 800°C = 1472°F.
> 100 kw/m^2 = 30,000 BTU/sq.ft.

IMPROVING COMBUSTION EFFICIENCY

A crucible furnace melts 2,000 lbs of aluminum per hour, flow meter readings indicate that 3,500 cu. ft. of gas per hour (3.5×10^6 BTU/hr.) is used.

Flue gas temperature was measured at 1150°F and the flue gas analysis showed a CO_2 content of 5%. Find present combustion efficiency and probable efficiency, by installation of a nozzle mix burner and fuel/air ratio controls, if CO_2 content was corrected to 11% and excess air reduced to 10%. For this example it has been assumed that furnaces are equipped with covers.

Present Combustion Efficiency

Heat required to melt aluminum,

- Heat content of metal is 500 BTU/lb (Figure No. 1)
- Amount of metal heated per hour is 2,000lb.

Therefore, Heat to product is 500 x 2000 = 1,000,000 BTU/hr.

Heat lost to exhaust.

- From Figure No. 2 with 5% CO_2 in flue gas the excess is approximately 130%.
- From Figure No. 3 with a flue gas temperature of 1150°F and 130% excess air, the percent of gross fuel input available to do work (including radiation losses) is approximately 40%.

Therefore, of the 3,500,000 BTU/hr. energy input only (3,500,000 x 0.4) 1,400,000 BTU/hr (minus the radiation losses) is utilized.

Propable Combustion Efficiency

Heat lost to exhaust

- From Figure No. 2 with 11% CO_2 in flue gas the excess air is 10% approximately.
- From Figure No. 3 with a flue gas temperature of 1150° and 10% excess air, the percent of gross fuel input available to do work (including radiation losses) is approximatly 65%.

Therefore, of the 3,500,000 BTU/hr. energy input (3,500,000 x 0.65) 2,275,000 BTU/hr. is available for melting the metal.

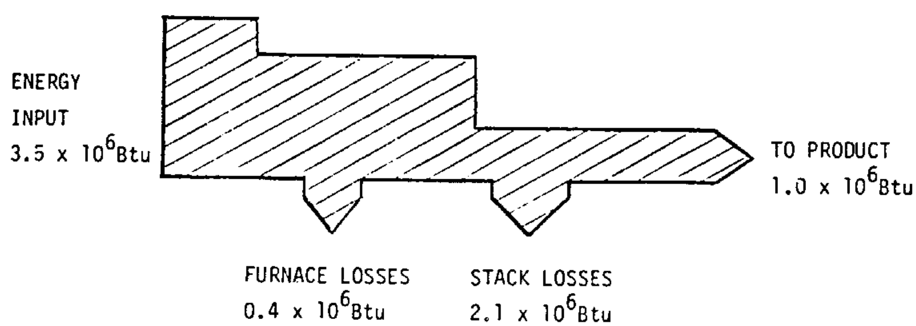
As previously stated the amount of heat required to melt 2,000 lbs. of aluminum is 1,000,000 BTU/hr. Present combustion efficiency calculations show that 1,400,000 BTU/hr. was available to melt the metal. Therefore: 1,400,000 - 1,000,000 results in 400,000 BTU/hr. being lost by radiation effects. By increasing the available fuel to 65% it can be readily seen that a smaller burner could be used to accomplish the same work.

$$\frac{875,000 \text{ BTU/hr.}}{350,000 \text{ BTU/hr.}} \times 100 = 25\% \text{ less fuel}$$

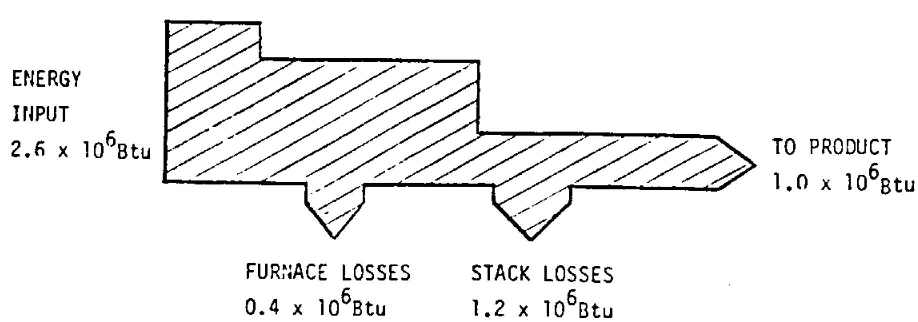
Summary

Item	Present Energy	Probable Energy
Heat to product	1,000,000 BTU/hr.	1,000,000 BTU/hr.
Heatloss to Stack	2,100,000 BTU/hr.	1,225,000 BTU/hr.
Heatloss (Radiation)	400,000 BTU/hr.	400,000 BTU/hr.
Gross Input	3,500,000 BTU/hr.	2,625,000 BTU/hr.

Process Energy Flow Diagrams

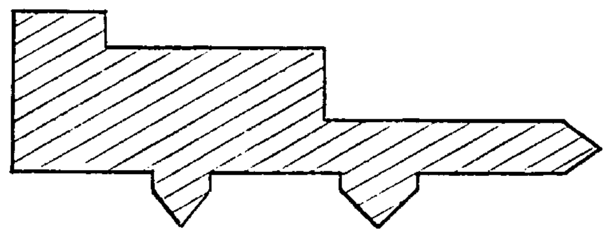


PRESENT CONDITION

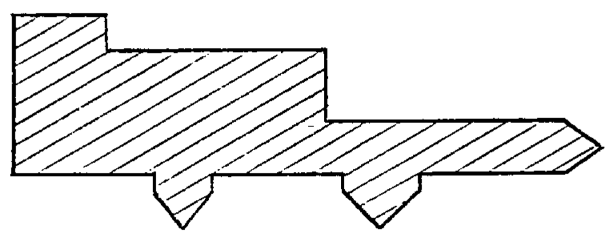


PROBABLE CONDITION

Process Energy Flow Diagrams



PRESENT CONDITION



PROBABLE CONDITION

Yearly Energy Cost Savings

Assuming, using the above example, that the furnace melted 8 hours per day, 5 days per week, 50 weeks per year then the energy and cost savings would be;

8 x 5 x 50 x 875,000 BTU/hr. = $\underline{1750 \times 10^6 \text{ BTU}}$ or 17500 therms/year, at $0.30 per therm, yearly savings would be $5,250

COMBUSTION AIR PREHEATING

For typical gas fired furnace with flow rate of 3.5×10^6 BTU/hr, improved efficiency can be attained by preheating the combustion air with the use of a hot gas recuperator.

Example Calculations

With flue gas temperature of 1600°F, if combustion air is preheated to 1200°F, energy savings of approx. 26% are available as obtained from Fig. 8 . Thus heat savings can be calculated for the typical gas fired furnace as follows:

2.625×10^6 BTU/hr. x 0.26 = 0.68×10^6 BTU/hr.

Annual energy reduction based on 8 hours/day, 240 days per year is-

$\frac{0.68 \times 10^6 \times 8 \times 240}{100{,}000 \text{ BTU/therm}}$ = 13,100 therms/yr. @ $0.3 per therm, cost reduction = $3,930/year.

Summary

Item	Present Energy	Probable Energy
Heat to Melt	1,000,000 BTU/hr.	1,000,000 Btu/hr.
Stack Losses*	1,225,000 BTU/hr.	545,000 BTU/hr.
Radiant Losses*	400,000 BTU/hr.	400,000 BTU/hr.
Gross Input	2,625,000 BTU/hr.	1,945,000 BTU/hr.

*Stack and radiant losses from previous example after improvements.

REFRACTORY MATERIALS - CRUCIBLE FURNACE

Sample Calculation -

A crucible furnace with composite refractory and insulating - concrete lining is compared to same furnace with ceramic fiber sleeve insulating material. Diagram of typical furnace with composite lining is shown in Fig. 6 .

The heat loss through composite material is determined by calculation of "Q"

$$Q \text{ per sq. ft.} = \frac{t_1 - t_2}{R_1 + R_2} \text{ etc.}$$

Where t_1 = Hot Face Wall Temperature.
t_2 = Cold Face Wall Temperature.
R = Resistance, which is the wall thickness divided by "K", the conductivity of the material.

"K" for various materials is obtained from table of typical thermal properties Fig. 4 . Thus $R_1 + R_2$ etc. for various thicknesses is:

$R1 = \frac{2}{16}$ (fused alumina)	$= 0.125$
$R2 = \frac{3}{6}$ (crushed firebrick)	$= 0.333$
$R3 = \frac{1}{1.2}$ (vermiculite)	$= 0.833$
Total $R_1 + R_2 + R_3$	$= 1.291$

Area of side walls estimated to be 110 sq. ft.

Thus heat loss through composite material = Qa

$$\therefore Qa = \frac{(3{,}000 - 100)\ 110}{1.291} = 247{,}000 \text{ BTU/hr.}$$

NOTE: The above calculation demonstrates the methodology used for computing sample radiation losses. Actual radiation losses used throughout the preceding examples is 400,000 Btu/Hr.

Replace 6" composite material with 6" ceramic fiber sleeve of 3,000°F maximum use temperature. The calculation of mean temperature =

$$\frac{t_1 - t_2}{2} = \frac{3{,}000 - 100}{2} = 1450°F$$

K value for mean temperature of 1450°F (from fig. 5) is prorated between 0.57 and 0.67 to be 0.60

thus R (ceramic fiber) $= \frac{6}{0.60} = 10$

Thus heat loss through ceramic fiber sleeve = Qb.

$$\therefore Qb = \frac{(3{,}000 - 100)\ 110}{10} = 31{,}900 \text{ BTU/hr}$$

Change in heat loss Qa - Qb = 247,000 - 31,900 = 215,100 BTU/hr

Based on a melt program of 8 hours/day, 240 days per year, the annual gas usage reduction is as follows:

$$\frac{215{,}100 \text{ BTU/hr} \times 8 \times 240}{100{,}000 \text{ BTU/therm}} \times \$0.3 = \$1{,}240\text{/year.}$$

If original energy input is 1.945 x 10^6 BTU/hr., the furnace efficency is improved from 51.4 per cent to approximately 57.8 percent, or 6.4% increase in efficiency.

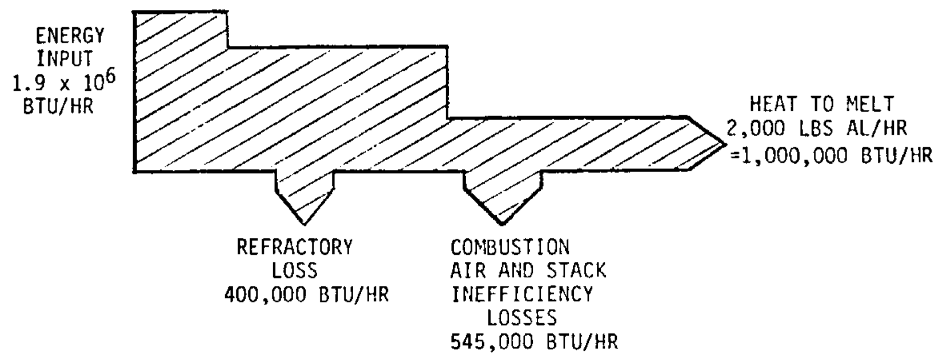
Summary

Item	Present Energy	Probable Energy
Heat to Melt	1,000,000 BTU/hr.	1,000,000 BTU/hr.
Radiation loss*	400,000 BTU/hr.	185,000 BTU/hr.
Stack Loss*	545,000 BTU/hr.	545,000 BTU/hr.
Gross Imput	1,945,000 BTU/hr.	1,730,000 BTU/hr.

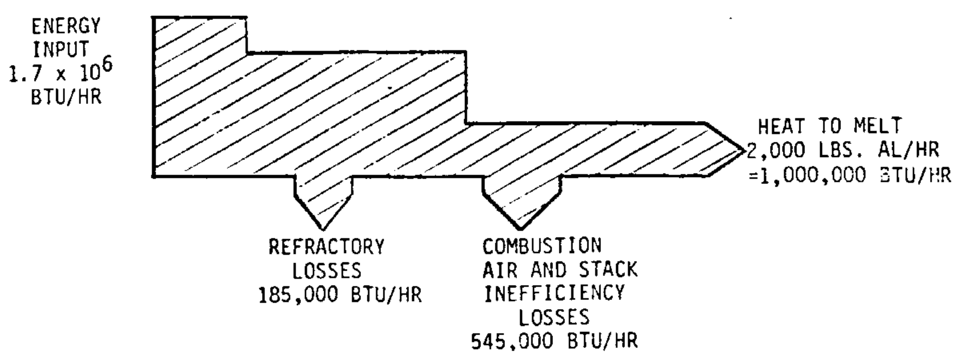
* Stack and radiant losses from previous example after improvements of combustion equipment.

TYPICAL ENERGY FLOW DIAGRAM

PRESENT CONDITION:



PROBABLE CONDITION:



FURNACE COVERS

Ladle and furnace covers eliminate most of the radiation loss which is the major area of energy loss from uncovered ladles and metal surfaces. Net radiated heat loss from a metal surface, emissivity, depends on the amount of slag. Emissivity of clean iron is relatively small but the thin slag layer usually present increases emissivity. Energy loss can be obtained by reference to Fig. 9 by reading net radiated power at metal temperature from the chart.

Example, at metal temperature of 800°C (1472°F), read for radiation at E = 1, net radiated power = 100 kw/m^2 (0.03×10^6 BTU/sq.ft.)

Where: $1\ m^2 = 10.76$ sq.ft.

1 kw = 3412 BTU.

Sample Calculation-

Consider a gas fired furnace holding aluminum at 1400°F with dip well area 4 sq. ft. without a cover and calculate the energy savings with a ceramic fiber cover in place.

Radiation losses, at 1400°F (760°C) from Fig. 9 = 60 kw/m^2

= 19,000 BTU/sq. ft.

Thus 4 sq.ft. x 19,000 BTU = 76,000 BTU/hr.

Heat loss from dip well with cover, based on thickness of two inches for ceramic fiber cover, is:

$$Q = \frac{t_1 - t_2}{R_1 + R_2} \text{ etc.}$$

where t_1 = hot face temp. 1400°F.
t_2 = cold face temp. 200°F.
R^2 = Resistance which is the thickness of the cover divided by the conductivity K.

K for cover material can be obtained from Fig. 5 where mean temperature of the material is given by

$$\text{Mean temp.} = \frac{t_1 - t_2}{2} = \frac{1400 - 200}{2} = \underline{600°F}$$

Thus K from Fig. 5 at 600°F = 0.26 (BTU/sq. ft. per ins - °F/hr.)

$$\therefore Q = \frac{(1400 - 200)}{2/0.26}\ 4 \text{ sq.ft.} = \frac{4800}{7.7} = 600 \text{ BTU/hr.}$$

Savings in energy loss = 76,000 - 600 = 75,400 BTU/hr.

With cover in place during 16 hours holding period per day, the reduction in energy for 240 days per year is:

$75,400 \times 16 \times 240 = 289 \times 10^6$ BTU/year @ \$0.3 per therm, the cost savings is:

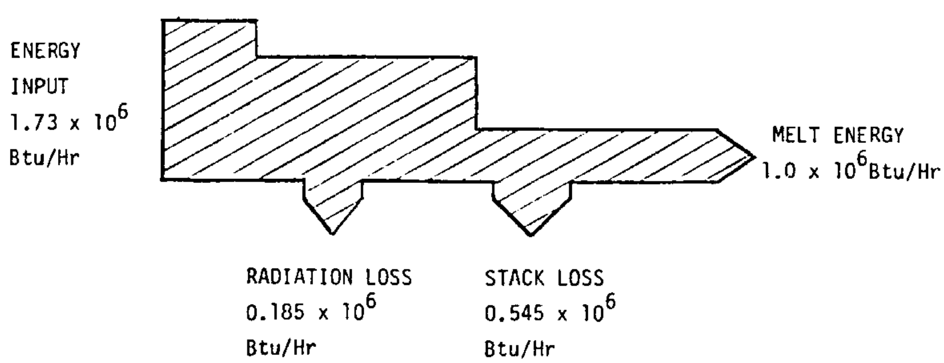
$$\frac{289 \times 10^6 \times 0.3}{100,000} = \underline{\$870 \text{ per year}}$$

Summary

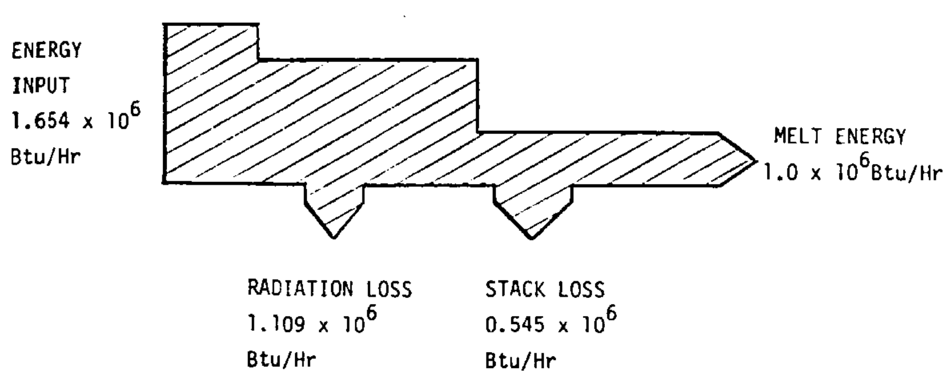
Item	Present Energy	Probable Energy
Heat to Melt	1,000,000 BTU/hr.	1,000,000 BTU/hr.
Radiation Loss*	185,000 BTU/hr.	109,600 BTU/hr.
Stack Loss*	545,000 BTU/hr.	545,000 BTU/hr.
Gross Input	1,730,000 BTU/hr.	1,654,600 BTU/hr.

*Stack losses and radiation loss from previous example for present conditions after improvements.

PRESENT CONDITION -



PROBABLE CONDITION -



OVERALL FURNACE EFFICIENCY

The following table summarizes the probable cost and energy savings by carrying out all of the possible improvements previously covered in the examples.

Summary (Energy and Cost Savings)

Item	BTU/hr. Reduction	Efficiency Percent Increase	Annual Gas Therms.	Savings Cost $
Combustion Efficiency	875,000	25.0%	17500	5250
Preheat Comb. Air	680,000	26.0%	13100	3930
Refractory Upgrade	215,000	6.4%	4130	1240
Furnace Covers	75,000	2.6%	2900	870
Total	1,845,000	31.8	37,630	$11,290

$$\text{Overall Thermal Efficiency} = \frac{1.0 \times 10^6}{(3.5 - 1.845)\ 10^6} \text{ X } 100 = 60.4\%$$

$$\text{Present Efficiency (Approximate)} = 28.6\%$$

$$\text{Increased Efficiency} = 60.4 - 28.6 = 31.8\%$$

$$\text{Percent Energy Saved} = \frac{1,845,000}{3,500,000} = 53\%$$

REVERBERATORY FURNACES

Energy savings and efficiency improvements can be developed for reverberatory furnaces. For combustion efficiency and burner preheating the previous examples are repeated and applied to reverberatory furnace summary analysis.

REFRACTORY MATERIALS - REVERBERATORY FURNACES

Sample Calculation-

Assume a reverberatory furnace melts 2,000 lbs of aluminum per hour. The area of refractory below metal is 40 sq. ft. and the area of refractory above metal is 40 sq.ft. Thickness of refractory is 6 inches. Metal is at 1380°F and combustion gas temperature above the metal is 3000°F. To find heat loss with conventional refractory, the thermal conductivity k for the material is determined from fig. 4 to be 6 BTU/hr. per sq. ft. (deg. F per inch.) for crushed firebrick.

Heat loss $Q = \dfrac{t_1 - t_2}{R_1 + R_2}$ etc.

Where t_1 = Hot face wall temperature
t_2 = Cold face wall temperature
R = Resistance, which is the thickness of the lining divided by the conductivity of the material K.

Mean temperature $\dfrac{t_1 - t_2}{2}$ is required to select K

Thus the mean temperature for area above the metal, based on a combustion gas temperature of 3000°F = $\dfrac{3000 - 100}{2}$ = 1450°F

Mean temperature for area below the metal = $\dfrac{1380 - 100}{2}$ = 690°F

∴ Qa (above the metal) = $\dfrac{3000 - 100}{6/6}$ = 2900 BTU/Hr/Sq.Ft.

= 2900 x 40 = 116,000 BTU/hr.

∴ Qb (below the metal) = $\dfrac{1380 - 100}{6/6} = \dfrac{1280}{1}$ = 1280 BTU/hr/sq.ft.

=1280 x 40 = 51,200 BTU/hr.

∴ Total heat loss through the refractory walls

= Qa + Qb = 116,000 + 51,200 = 167,200 BTU/hr.

To find the heat loss with ceramic lining used for insulation between the refractory and the outer shell, the added R, resistance, must be calculated.

The thermal conductivity K for ceramic fiber is determined from Fig. 5 for 1 inch thick material to be 0.26 BTU/hr. per sq. ft. (deg. F per inch.)

Note - Mean temperature assumed between refractory and shell, $t = 200°F$.

$$\therefore \text{ New heat loss } Qa + Qb = \frac{(t_{1a} - t_2)\ 40}{6/6 + 1/0.26} + \frac{(t_{1b} - t_2)\ 40}{6/6 + 1/0.26}$$

$$= \frac{(3000 - 100)\ 40}{1 + 3.84} + \frac{(1380 - 100)\ 40}{1 + 3.84} = 23{,}970 + 10{,}600$$

$= \underline{34{,}570 \text{ BTU/hr.}}$

Change in heat loss through lining by adding 1 inch of ceramic fiber insulation = 167,200 - 34,570 = 132,630 BTU/hr. reduction, equivalent to 79.3% saving.

Based on a melt program of 8 hours per day, 240 days per year, the annual gas cost reduction is as follows:

$$\frac{132{,}600 \text{ BTU/hr.} \times 8 \times 240}{100{,}000 \text{ BTU/therm}} \times \$0.3 = \underline{\$760}$$

Summary

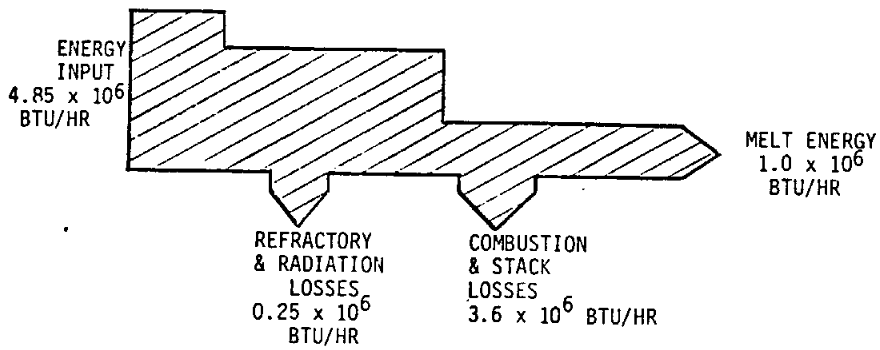
Item	Present Energy	Probable Energy
Heat to Melt	1,000,000 BTU/hr.	1,000,000 BTU/hr.
Radiation Losses*	250,000 BTU/hr.	117,000 BTU/hr.
Combustion and Stack Losses*	2,045,000 BTU/hr.	2,045,000 BTU/hr.
Gross Input	3,295,000 BTU/hr	3,162,000 BTU/hr.

* Combustion and stack losses from previous example after improvements are listed in this case for present energy use.

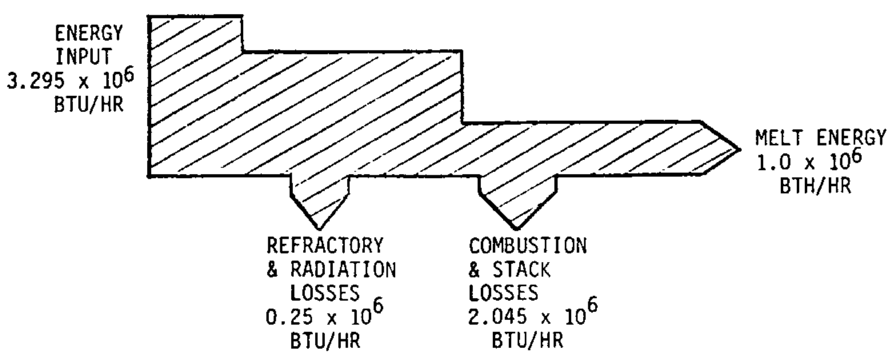
Energy flow diagrams for all improvements by progression from original condition to ultimate condition are as follows:

Energy Flow Diagrams - Reverberatory Furnace Example

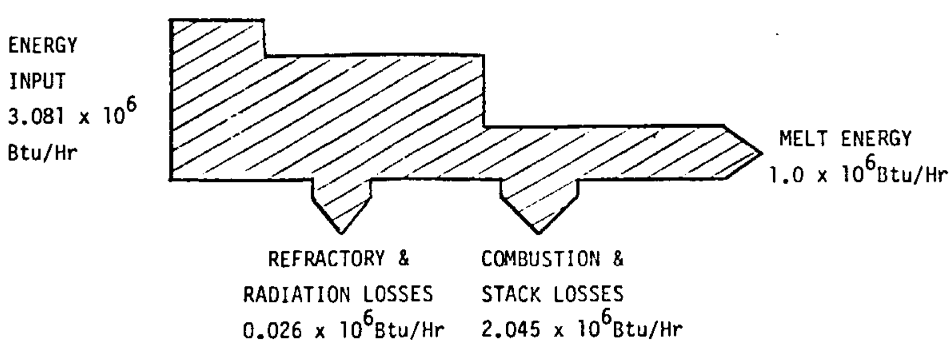
ORIGINAL CONDITION:



COMBUSTION IMPROVEMENT & BURNER AIR PRE-HEAT



REFRACTORY & METAL COVERS IMPROVEMENTS



OVERALL FURNACE EFFICIENCY

The following table summarizes the probable cost and energy saving available by carrying out all of the possible improvements in common with the crucible furnace per previous examples.

Summary (Energy and Cost Savings)

ITEM	BTU/HR REDUCTION	% ENERGY SAVING	ANNUAL GAS THERMS	SAVINGS COST $
Combustion Efficiency*	875,000	25.0%	17,500	5,250
Preheat Combustion Air	680,000	26.0%	13,100	3,930
Refractory Upgrade	132,000	4.0%	2,550	760
Furnace Covers	75,000	2.1%	2,900	870
TOTAL	1,762,000		36,050	$10,810

Overall percent energy reduction $= \frac{1,762,000}{4,850,000} = 36.3\%$

Overall thermal efficiency $= \frac{1.0 \times 10^6 \times 100}{(4.85 - 1.762 \times 10^6)} = 32.3\%$

Present efficiency (approximate) = 20.6%

Increased efficiency = 32.3 - 20.6 = 11.7%

ECONOMIC EVALUATION	CRUCIBLE FURNACE	REVERBERATORY FURNACE
1. Replace existing burner system with a combination nozzle mix burner system-recuperator package with completely pre-wired control system Equipment Cost	$ 30,000.00	30,000.00
2. Replace conventional refractory lining with ceramic fiber material	$ 2,000.00	500.00
3. Metal covers in ceramic fiber material	$ 200.00	200.00
4. Labor to install Item 1	$ 17,000.00	17,000.00
5. Engineering Costs	$ 5,000.00	5,000.00
TOTAL	$ 45,000.00	43,000.00

Payback period $= \dfrac{\text{Capital Investment}}{\text{Energy Savings \$/YR}} = \underline{\text{Years}}$

Therefore payback period (present day costs)

Crucible Furnace $= \dfrac{45{,}000}{11{,}290} = 3.98$ years

Reverberatory Furnace $= \dfrac{43{,}000}{10{,}850} = 3.98$ years

NOTE - The above costs are for example only, actural equipment costs are to obtained for specific furnace item as part of normal engineering procedure. Labor costs for lining installations are assumed to be covered by normal maintenance expense budget.

HEAT TREATING

General Considerations

This section, dealing with the energy savings of the Heat Treat Furnace operation, will concentrate generally on the major areas for energy savings attributed to:

- Process operation and control
- Refractory materials
- Combustion equipment
- Heat recuperation

Formulas, calculations, and graphs have been simplified within the Scope of the Project from the normally complex task of calculating heat transfers, to reflect constant conditions during the process.

To investigate any process in depth it is essential to establish parameters, calculate the data and plot results on a continuous basis to establish the limits of the operation and equipment, and identify any trends.

The work sheet lists the expected parameters for furnace shell, blower, burner and ancillary equipment, and operational data to complete a "one shot" energy audit and constitute a base for any future improvements. A tape measure, thermometer, flue gas analyzer and flow meters will be the tools needed.

HEAT TREAT DATA INPUT

HEAT TREATING UNIT NO.1

FURNACE MAKE ANY	BURNER MAKE ABC
MODEL ANY	MODEL ABC
SIZE 10' x 20' x 8' HIGH	TYPE Pre mix SIZE ____ BTU/HR
CAPACITY 20,000 LBS.	FUEL Natural Gas
TYPE OF LINING Conventional	RECUPERATOR MAKE None
WALL THICKNESS 13½ INCH	MODEL - TEMP - °F
BLOWER MAKE ____	TYPE - SIZE -
MODEL ____	CONTROLS MAKE None
SIZE ____ CFM. PRESS ____ "WG	TYPE -
VOLT ____ HP ____	

TYPE OF HEAT TREAT CYCLE ____ ALLOY ____

HEAT TREAT CYCLE - HEATUP ____ HRS	FUEL/AIR RATIO Un-controlled
- SOAK ____ HRS	FLUE TEMPERATURE HIGH 1650 °F LOW ____ °F
-COOL DOWN ____ HRS	SHELL MEAN TEMPERATURE ____ °F
CYCLES PER WEEK ____	FURNACE PRESSURE Negative "WC
TEMPERATURE 1,650 °F	
AVERAGE LOAD ____ LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING ____ LBS	N/A % O_2
BASKETS ____ LBS	5 % CO_2
STOOLS ____ LBS	
LOAD DENSITY ____ LBS/WFT	
QUENCH ____ AIR, ____ H20 ____ OIL	
QUENCH TEMPERATURE ____ °F	FUEL CONSUMPTION 116 THERMS/CYCLE

MISCELLANEOUS

WALL AREA 880 SQ.FT.

WALL TEMPERATURE HOT FACE T_1 1650 °F

WALL TEMPERATURE COLD FACE T_2 160 °F

AMBIENT TEMPERATURE 80 °F

EXTERNAL SURFACE AREA 880 SQ.FT.

HOT SURFACE AREA 570 SQ.FT.

ENERGY COST/THERM $ 0.30

HEAT TREAT LOADS/DAY ____

HEAT TREAT LOADS/YEAR ____

Note: Data Recorded is only that needed to perform sample calculations.

TABLES, GRAPHS AND CHARTS

Table I

APPROXIMATE THERMAL CONDUCTIVITIES
OF FIRECLAY BRICK

Btu per Hour, per Square Foot, per Degree F. Temperature Difference, for One-Inch Thickness

Kind of Brick	Density*	Mean Conductivity at T°F.													
		200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800
	147	9.7	9.7	9.7	9.8	9.9	10.0	10.2	10.3	10.5	10.7	10.9	11.1	11.3	....
	146	8.7	8.8	9.0	9.1	9.3	9.4	9.6	9.7	9.9	10.0	10.2	10.4	10.5	....
	136	8.4	8.5	8.7	8.8	9.0	9.2	9.3	9.5	9.6	9.8	9.9	10.1	....	....
	127	7.1	7.3	7.4	7.6	7.8	8.0	8.1	8.3	8.5	8.7	8.8	9.0	....	....
	125	5.8	6.2	6.5	6.9	7.3	7.6	8.0	8.3	8.7	9.0	9.4	9.8	....	....

*Pounds per Cubic Foot.

NOTE: For brick of the same type, class, composition, and burn, the conductivities are approximately proportional to the bulk densities (weights in pounds per cubic foot).

Table II

APPROXIMATE THERMAL CONDUCTIVITIES
OF INSULATING FIREBRICK

Btu per Hour, per Square Foot, per Degree F. Temperature Difference, for One-Inch Thickness

Density*	Thermal Conductivity at T°F													
	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800
36	1.06	1.20	1.34	1.48	1.63	1.77	1.91	2.05	2.19	....	....	....	....	....
38	1.26	1.40	1.54	1.63	1.83	1.97	2.11	2.25	2.40	....	....	....	....	....
46	1.44	1.59	1.75	1.91	2.06	2.22	2.38	2.53	2.69	2.85	3.00	....	....	....
31	0.78	0.86	0.94	1.02	1.09	1.17	1.25	1.33	1.41	1.48	1.56	....	....	....
49	1.83	1.98	2.13	2.28	2.43	2.58	2.73	2.88	3.03	3.18	3.33	3.48	....	....
56	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00	3.15	3.30	3.45	3.60	3.75	3.90
60	2.20	2.35	2.50	2.65	2.80	2.95	3.10	3.25	3.40	3.55	3.70	3.85	4.00	4.15

*Pounds per Cubic Foot

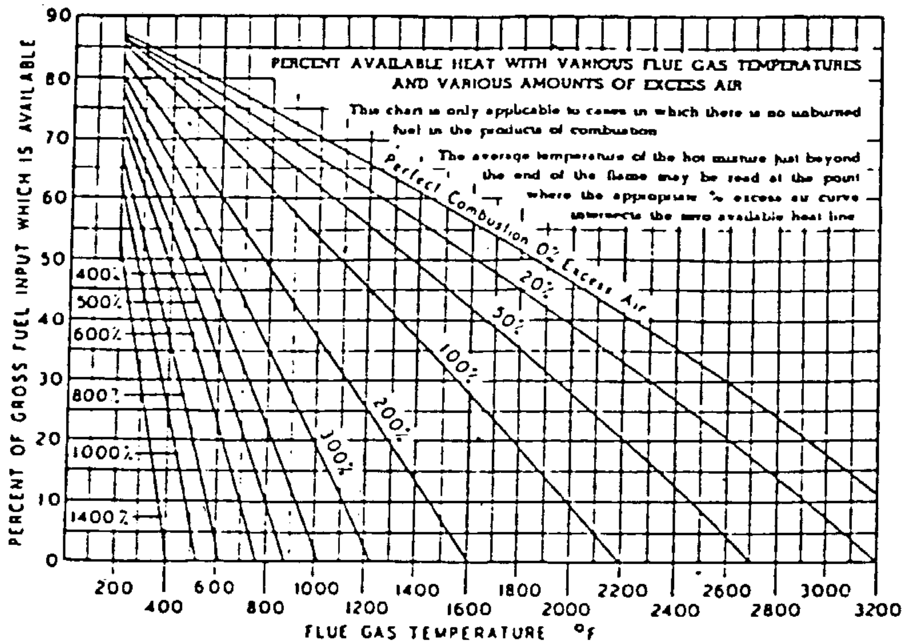


FIGURE 1. PERCENT AVAILABLE HEAT*

Example of use: With a flue gas temperature of 1100 F and an excess air requirement of 90%, the amount of heat available (including heat loss by radiation) is approximatly 52%.

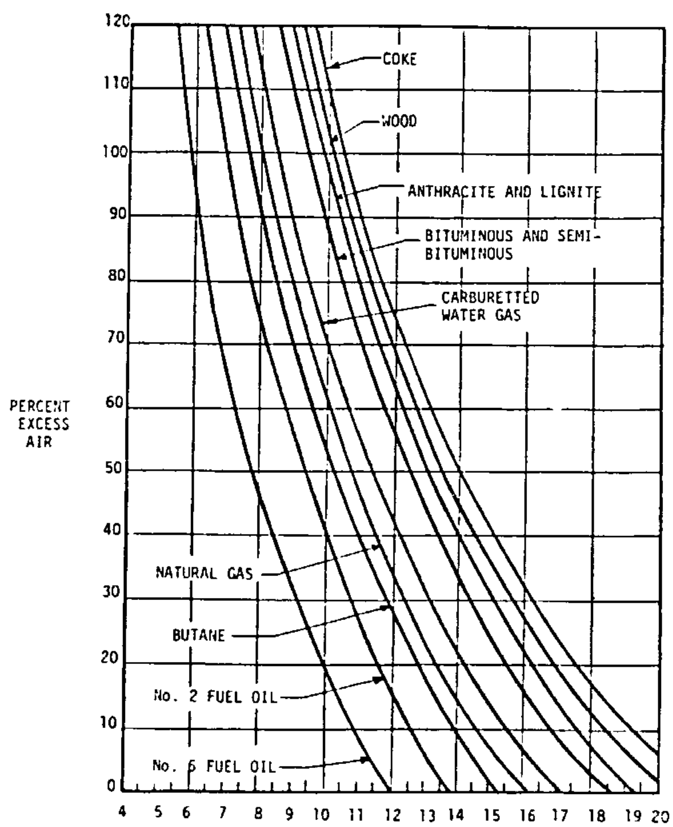


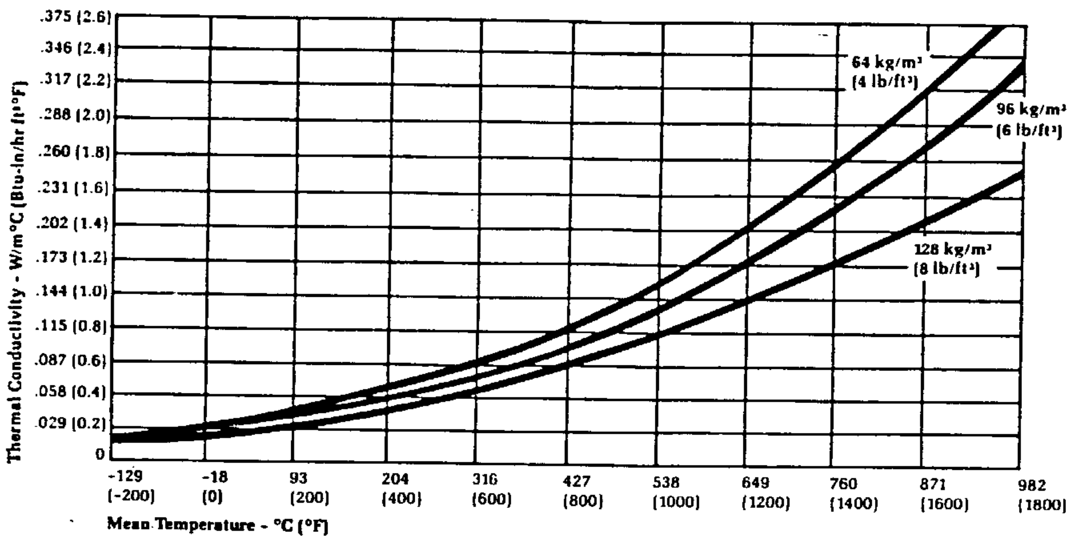
FIGURE 2. PERCENT EXCESS AIR FROM CO2 READING*

Example of Use: A combustion analysis shows 6% CO_2 content of the flue gas, with natural gas burning equipment the excess air is approximately 90%.

*From North American Combustion Handbook

Table III CERAMIC FIBERS

Thermal Conductivity vs Mean Temperature (per ASTM C-177)**



**All heat flow calculations are based on a surface emissivity factor of .90, an ambient temperature of 27°C (80°F), and zero wind velocity, unless otherwise stated. All thermal conductivity values for Fiberfrax materials have been measured in accordance with ASTM Test Procedure C-177. When comparing similar data, it is advisable to check the validity of all thermal conductivity values and ensure the resulting heat flow calculations are based on the same condition factors. Variations in any of these factors will result in significant differences in the calculated data.

Heat storage and losses can be approximated based on the following Table IV.

Table IV HEAT STORAGE AND LOSSES BTU/SQ. FT.

Table IV

HEAT STORAGE AND LOSSES BTU/SQ. FT.

WALL THICKNESS	TYPE REFRACTORY	HOT FACT TEMPERATURE °F					
		1,200		1,600		2,000	
		H. ST.	H.L.	H. ST.	H.L.	H. ST.	H.L.
9"	Composite 2,000° insulation and firebrick	13,700	285	19,200	437	24,800	615
13-1/2"	Composite 2,000° insulation and firebrick	22,300	335	31,400	514	40,600	718
22-1/2"	Composite 2,000° insulation and firebrick	43,200	182	61,000	281	79,200	392
6"	Ceramic fiber	842	208	1,170	432	1,490	672

H. ST. - Heat Stored
H. L. - Heat Lost Btu/hr

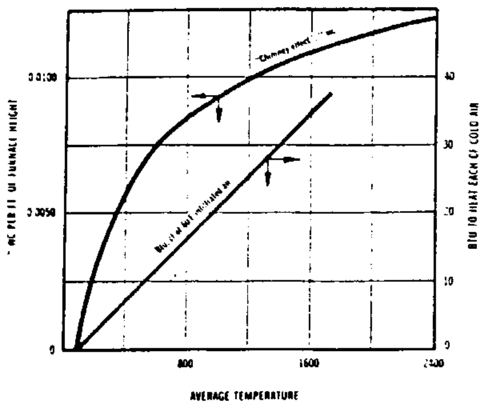


FIGURE 3A

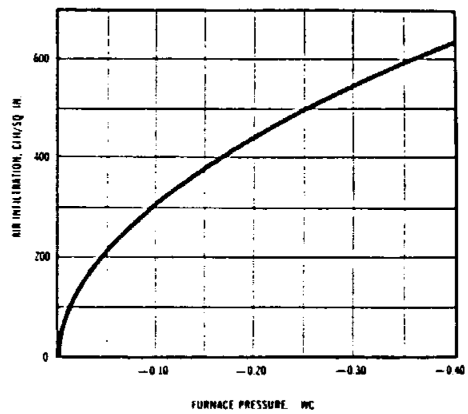


FIGURE 3B

Courtesy of american Gas Association

Above table to be used for calculating air infiltration through cracks.

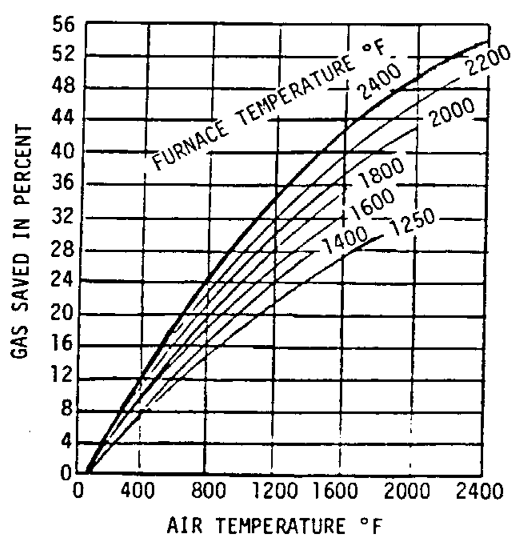


FIGURE 4. Preheating of Combustion Air*

*From AGA Catalog

SAMPLE CALCULATIONS (Energy Related)

Upgrading Furnace Linings.

Heat loss through various refractory linings can be calculated by the use of the following mathematical formula:

$$\text{HEAT LOSS "Q"} = \frac{t_1 - t_2}{R_1 + R_2} \text{ etc.}$$

WHERE:

t_1 = Hot face wall temperature

t_2 = Cold face wall temperature

R = Resistance, which is the thickness of the lining divided by the conductivity of the material "K"

Typical values of "K", thermal conductivity in Btu/hr, per square foot, per degree "F" temperature difference, for one inch thickness are listed in Tables I and II for fire clay and brick refractories.

"K" values for ceramic fiber linings are shown in Table III.

The heat required to get refractories up to furnace operating temperature (heat storage effect) is listed in Table IV.

To obtain "K" factors from Tables I, II, and III it is necessary to calculate the mean temperature. This is accomplished by adding t_1 and t_2 and dividing by 2. Thus mean temperature for this set of conditions is:

$$\frac{1650^{\circ}F - 160^{\circ}F}{2} = 905^{\circ}F.$$

Example: Determine heat loss through furnace walls lined with:

(a) Conventional brick refractory lining

(b) Laminated ceramic lining

(c) Full ceramic fiber lining

(a) Conventional refractory lining is composed of the following materials:

- 9" fire brick with a density of 147 lbs/cu. ft.
- 4-1/2" insulated brick with a density of 31 lbs/cu. ft.

Therefore:

$$\text{Heat Loss} = \frac{1650 - 160}{.91 + 4.24^{1/}} = \underline{289 \text{ Btu/hr/F}^2}$$

1/ To find resistance "R" for insulated brick, enter Table II at 905^{0}F (mean temperature) and read down to the 31 lb. density column, the resultant "K" factor is approximately 1.06,

$$\text{therefore R} = \frac{4\text{-}1/2}{1.06} = 4.24$$

Total heat loss through furnace walls:

= 289 Btu/hr/ft^2 x 570 Sq. ft. = <u>164,730 Btu/Hr</u>.

(b) Laminated refractory lining is composed of:

- 9" fire brick with a density of 147 lb/cu. ft.
- 4-1/2" insulated brick, density of 31 lbs/cu. ft.
- 1" ceramic fiber lining, density of 8 lb/cu. ft.

Therefore:

$$\text{Heat Loss} = \frac{1650 - 160}{.91 + 4.24 + 1.43} = \underline{226} \text{ Btu/hr/F}^2$$

Total heat loss through furnace walls:

= 226 Btu/Hr/F^2 x 570 Sq. Ft. = <u>128,820</u> Btu/hr.

(c) Full ceramic fiber lining, composed of the following:

- 12" ceramic fiber at 8 lbs. density/cu. ft.

Therefore:

$$\text{Heat Loss} = \frac{1650 - 160}{17.14^{2/}} = 87 \text{ Btu/hr/F}^2$$

2/ To find resistance "R" for ceramic fiber, enter Table III at 905°F., extend up to the 8 lb. density column and read 0.7 at the left hand side of the graph, therefore:

$$R = \frac{12}{0.7} = 17.14$$

Total heat loss through furnace walls:

= 87 Btu/hr/Ft^2 x 570 Sq. Ft. = 49,590 Btu/hr.

Summary - Heat Loss for Various Linings

ITEM	Btu/hr	% Savings over Basic Refract.
Conventional Refractory	164,730	-0-
Laminated Refractory	128,820	22%
Ceramic Fiber	49,590	70%

Equivalent total gas usage reduction, utilizing ceramic fiber lining, is 164,730-44,590 = 115,140 Btu/hr or 1.15 Therms per hour.

Based on a continuous heat treat operation (with furnace in equilibrium) of 16 hours per day, 5 days per week-50 weeks per year, the total yearly gas savings would be as follows:

$$\frac{115{,}140 \text{ Btu/Hr} \times 16 \times 5 \times 50}{100{,}000 \text{ Btu/Therm}} \times \$0.3 = \$\underline{1{,}382.00} \text{ per year}$$

Batch type heat treat operation is very costly in terms of gas usage due to the input energy required to heat the refractory mass up to furnace operating temperature, the following table illustrates the amount of energy required to heat the refractory to 1,600°F. versus that required for ceramic fiber:

ITEM	1/Heat Capacity Stored - Btu 3	% Savings over Basic Refractory
Conv. Refractory (13-1/2")	17,898,000	
Ceramic fiber (12")	1,333,800	92.5%

1/ Based on 570 sq. ft. inside furnace area and heat storage figures from Table IV.

Operating batch furnaces on a rapid change-over schedule will realize substantial fuel savings, also consideration must be given to the product to be processed. The scheduling effort to load to design capacity will be more than offset by the fuel savings obtained by reduced heating of the lining.

Quantative figures for overall savings, as a percentage of gas input to furnace, for upgrading conventional lining cannot be stated due to the many variables encountered in actual heat treat practices as applied to individual foundry operations. Savings shown in the example calculations, for lining replacements is attributed to radiation loss savings only.

Improving Combustion Efficiency.

A Heat Treat Furnace has the following characteristics (from input data sheet):

- Furnace size: 20' x 10' x 8 ft. high.
- Furnace capacity: 20,000 Lbs.
- Operating temperature: 1,650^{O}F.
- 5% CO_2 in flue gas.
- Flue gas temperature: 1,650^{O}F.
- Natural gas flow rate: 116 Therms/Hr. or 11,600 cu. ft.
- Furnace physical condition: 1/4" crack visible all around door.

Calculate present combustion and furnace efficiency and probable furnace efficiencies if the furnace was upgraded as follows:

- Install nozzle mix burners with flue/air ratio controls.
- Install furnace pressure controls.
- Install hot gas recuperator for preheating combustion air.
- Repair furnace door and seal cracks.

Example No. 1: Calculate present excess air and available heat.

Excess air through burner system with 5% CO_2 in flue gas (from Figure 2) is 130%.

Therefore, available heat to do work, (from Figure 1) with 130% excess air and 1,650^{O}F. flue gas temperature, is 20% of 11,600 cu. ft./Hr of natural gas which is:

11,600 cu. ft/Hr x 0.20 = 2.320 cu. ft/Hr or 2,320,000 Btu/Hr

Example No. 2: Calculate secondary excess air infiltration due to door leakage.

From Table 3A with an average furnace temperature of 1,650^{O}F., the furnace negative pressure due to chimney effect is 0.011" WC per foot of furnace height.

Therefore, total negative pressure is 0.011 x 8 = 0.088" WC.

From Table 3B with a total furnace negative pressure of 0.088, the air infiltration is approximately 280 cubic feet per hour per square inch of crack opening.

Therefore, total crack opening is, based on 28 linear feet of door circumference, 336 inches x 1/4" = 84 sq. inches.

From Table 3A with an average furnace temperature of 1,650°F., approximately 35 Btu is necessary to heat each cubic foot of infiltrated air, therefore, total heat required is:

35 Btu x 84 sq. inches x 280 cu. ft/Hr/Sq. inch = 823,200 Btu/Hr.

Present Combustion Efficiency.

From Example 1.	Available Heat	= 2,320,000 Btu/hr.
From Example 2.	Heat Lost (Infiltration)	= 823,200 Btu/hr.
Net Heat Available		= 1,496,800 Btu/hr

$$\text{Efficiency} = \frac{1{,}496{,}800}{11{,}600{,}000} \times 100 = 12.9\%$$

Example No. 3: Calculate probably combustion efficiency after installing new burner system and sealing furnace cracks. CO_2 content corrected to 11% and positive pressure maintained in furnace.

Available heat to do work (from Table 1) with 10%.

Excess air is 53% x 11,600,000 Btu/hr = 6,148,000 Btu/hr

Net increase in heat content available is:

6,148,000 Btu/hr - 1,496,800 Btu/hr = 4,651,200 Btu/hr

or 75.65% increase

Based on 5 days per week, 50 weeks per year heat treat operation with heat-up time averaging 6 hours, the yearly energy savings would amount to:

$$\frac{4{,}651{,}200 \text{ Btu/hr} \times 5 \times 50 \times 6}{100{,}000 \text{ Btu/Therm}} = 69{,}000 \text{ Therms per year.}$$

At $0.3 per therms, dollar savings would be $20,700/year

Combustion Air Preheating

From the preceding examples approximately 5,452,000 Btu/hr (11,600,000 - 6,148,000) is lost through the exhaust stack and radiation losses through the furnace walls. By preheating the combustion air with the use of a hot gas recuperation, the following additional energy savings can be realized

Example No. 4: With flue gas temperature of 1650^{0}F, calculate the energy savings if combustion air is preheated to 1200^{0}F.

From figure No. 4 the resultant fuel savings will amount to approximately 28%.

Therefore; additional heat saved per hour

$$= 0.28 \times 11{,}600{,}000 \text{ Btu/hr} = 3{,}248{,}000 \text{ Btu/hr}$$

Annual energy saving, using same operating time as stated in example 3, is:

$$\frac{3{,}248{,}000 \text{ Btu/hr} \times 1{,}500 \text{ Hrs.}}{100{,}000 \text{ Btu/Therm}} = 48{,}000 \text{ Therm/yr}$$

At $0.3 per therm, dollar savings would amount to $14,400

Overall Furnace Efficiency

The following table summarizes the possible cost and energy savings by upgrading existing furnace.

Item	Btu/hr Saved	ENERGY SAVINGS PERCENT	Annual Gas Savings	
			Gas (Therms)	Cost
Furnace Radiation Losses	115,140	70%	4,600	$1,382
Improve Comb. Efficiency	4,651,000	53%	69,000	$20,700
Pre-heat Combustion Air	3,248,000	28%	48,000	$14,400
Total	8,014,140		121,600	$36,482

$$\text{Overall Energy Savings} = \frac{8{,}014{,}140}{11{,}600{,}000} \times 100 = 69\%$$

Note: The foundry industry, in general, is experiencing between 50 to 60% actual Energy Savings by upgrading their present heat treat furnaces. Energy calculations in Section III of this study are based on 56% savings.

Summary

It must be restated that this analysis has been oversimplified to illustrate the need for improving existing thermal efficiency. The examples used can be a valuable tool in estimating potential savings. A full heat balance and thermal analysis should be made by an expert in this field before a major conversion is made. The energy savings are there if product requirements can be adjusted toward that goal.

Economical Evaluation

(a) Replace existing burner system with a combination nozzle mix Burner system - recuperator package with completely pre-wired control system. (Equipment Cost).............$90,000

(b) Replace conventional refractory lining with 12" thick ceramic fiber insulation - material cost..............$15,000

(c) Labor to install item No. 1*.......................$40,000

(d) Engineering costs.................................$10,000

Total...$155,000

$$\text{Pay Back Period} = \frac{\text{Capital Investment}}{\text{Energy Savings Cost}} = \underline{\quad\quad} \text{ yrs.}$$

$$\text{Therefore: Pay Back} = \frac{\$155{,}000}{36{,}482} = 4.25 \text{ years}$$

The above pay back period does not take into account future cost of natural gas which could increase as high as 15% per year, or government tax credits for installation of energy saving devices.

*Installation labor does not include the relining of the furnace. It is assumed that this labor would be performed by foundry maintenance personnel and expensed.

LADLE HEATING

General

Ladle Heating is a very necessary requirement in any castmetal operation, it is a large user of natural gas and is probably the greatest abuse of gas energy in foundries today. This Section will examine the requirements for upgrading or replacing existing equipment for ladle drying and heating, covering the following:

- Ladle covers
- Burner efficiencies
- Improved insulation

Formulas, calculations, and graphs have been simplified within the scope of the project from the normally complex task of calculating heat transfers, to reflect constant conditions during the process.

To investigate any process in depth it is essential to establish parameters, calculate the data and plot results on a continuous basis to establish the limits of the operation and equipment, and identify any trends.

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

LADLE CAP TONS 1.0 HEAT CYCLES/DAY 3

LADLE AREA INSIDE 12 SQ FT. LINING THICKNESS 2.5 ins.

COVERED No TYPE OF LINING Firebrick

INSIDE TEMP 1560 ^{o}F OUTER SHELL TEMP 300 ^{o}F

AMBIENT TEMP N/A ^{o}F

GAS USAGE/HR 550 CU FT. CO_2 READING N/A

COMBUSTION AIR N/A CFM PRESSURE -- WG

PREHEAT CYCLE TIME 1.0 HRS FLUE TEMP -- ^{o}F

REFRACTORY K VALUE 6 RS VALUE 0.33

BLOWER HP N/A RECUPERATOR EFFCY --

FUEL COST/THERM $ 0.3 ANNUAL USE N/A BTU x 10^6

NUMBER OF UNITS IN USE 1

GRAPHS, TABLES AND CHARTS

Figure 1 shows typical relationship of time versus temperature to fuel input for uncovered and covered ladles both with tight fitting and raised covers.

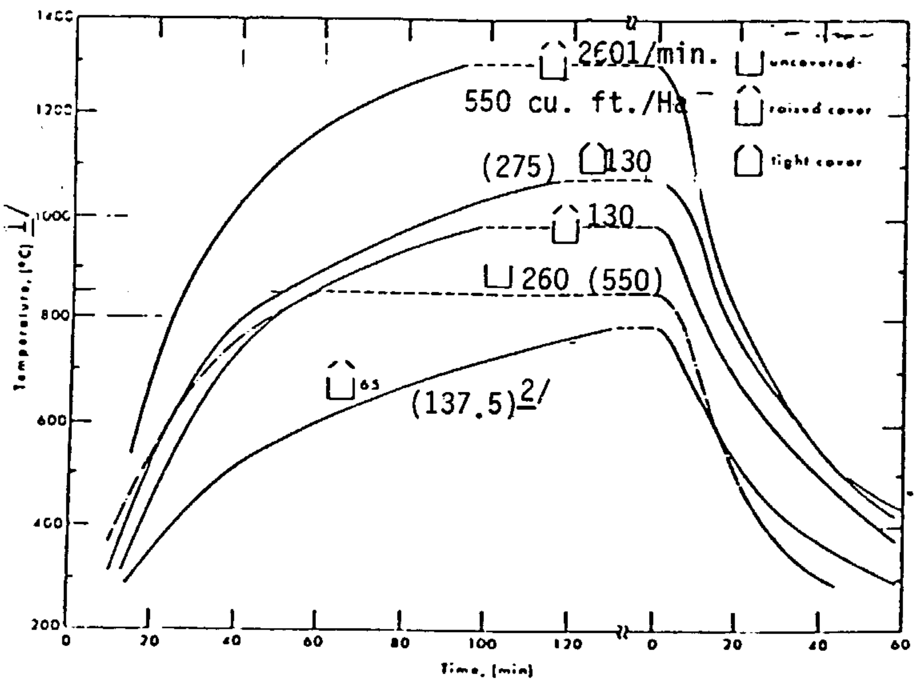


Figure No. 1

1/ Temperatures both in °C and °F at the inside bottom of the ladle.

2/ Figures shown are gas flow rates in liters per min. and cubic feet per hour.

Example of use: Curve is developed for specific ladle size with measured gas flow rates.

Read elapse time from intersection of curve with temperature.

For covered ladle at 275 cu. ft/hour gas flow, the time to attain required temperature 850°C, is approximately 50 minutes.

Figure 2

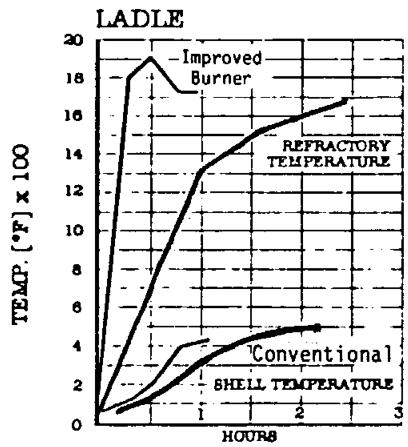
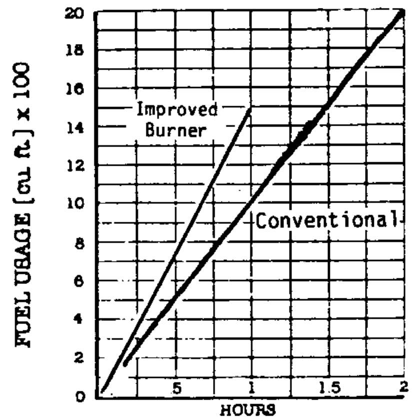


Figure 3



Reference: Hotwork Mfg. Inc.

Example of use:

Figure 2: Read elapsed time hours at intersection of temperature with improved burner graph line; then,

Figure 3: Obtain fuel usage for improved burner by reading up from elapsed hours to intersection with graph line and across to fuel usage.

For example: At temperature requirement of 1300°F, read approximately 0.25 hours (for improved burner) from Figure 2.

Transfer hours (0.25) onto Figure 3 and read approximately 400 cu. ft. fuel used by improved burner.

Table 1

8 – Typical Thermal Properties of Refractory and Insulating Concretes (Mix proportions approx. 1 vol. cement: 3 - 4 vols. aggregate).

Aggregate.	Fired density, lb. per cub. ft.	Heat capacity, B.t.u. per (cub. ft.) (deg. F.)	Thermal conductivity, B.t.u. per (hr./sq. ft.) (deg. F. per in.)	Thermal diffusivity, (sq. ft. per hr.)
Vermiculite	35	9	1.2	0.011
Diatomite	55	14	1.7	0.010
Crushed H.T. insulating brick	85	21	3.2	0.013
Expanded clay	90	22	3.5	0.013
Crushed firebrick	115	29	6	0.017
Molochite	120	31	8	0.021
Sillimanite	135	33	10	0.025
Carborundum	145	40	50	0.103
Calcined bauxite	160	45	12	0.022
Magnesite	160	45	20	0.037
Chrome-magnesite	165	37	8	0.013
Fused magnesia	170	50	24	0.04
Fused alumina	175	52	16	0.026
Bubble alumina	95	22	6	0.023

Thermal Conductivity (Table 2)

	2100	2400	2600	2800	3000
Maximum Recommended Use Temperature	2100°F (1150°C)	2400°F (1315°C)	2600°F (1425°C)	2800°F (1540°C)	3000°F (1650°C)
Density (PCF)	12-15	18-22	18-22	18-22	18-22
Thermal Conductivity - k (BTU - In./S.F. - °F - Hr.)			Same k values for these compositions.		
Mean Temperature °F 600°F	0.26	0.29			
800°F	0.36	0.35			
1000°F	0.48	0.41			
1200°F	0.62	0.48			
1400°F	0.77	0.57			
1600°F	0.93	0.67			
1800°F	1.08	0.79			
2000°F	1.24	0.93	"k" measurements made at Refractories Research Center, Ohio State University.		
2200°F	–	1.10			
2400°F	–	1.30			

* Ref. Industrial Insulations Inc.

SAMPLE CALCULATIONS (Energy Related)

LADLE COVERS:

Heat loss during pre-heat of ladle relates to time in attaining required temperature measured at the inside bottom of the ladle.

Typical burner sizes for average ladle capacities of 1 ton (iron) is 1.0×10^6 Btu/hr. Therefore energy savings for any capacity ladle can be pro-rated based on pre-heat time for any size burner.

Example:

Burner size 1" (1.0×10^6 Btu/hr) shows a gas flow rate of 275 cu.ft./hr.

The elapsed time to attain 850°C (1560°F) with the tight-cover ladle, is approximately 50 minutes, reference Figure 1.

$$\text{Thus gas usage} = \frac{50}{60} \times 275{,}000 = 0.230 \times 10^6 \text{ Btu}$$

The elapsed time to attain 850°C (1560°F) with a raised cover ladle utilizing gas flow rate of 275 cu.ft./hr, is approximately 50 minutes, reference Figure 1.

$$\text{Thus gas usage} = \frac{60}{60} \times 275{,}000 = 0.275 \times 10^6 \text{ Btu}$$

The elapsed time to attain 850°C (1560°F) with an open ladle utilizing gas flow rate of 550 cu.ft./hr is approximately 60 minutes, reference Figure 1.

$$\text{Thus gas usage} = \frac{60}{60} \times 550{,}000 = 0.55 \times 10^6 \text{Btu}$$

Relative savings for the alternate arrangements is:

Item	Btu's	Change in energy
Uncovered ladle	550,000	-0-
Raised cover ladle	275,000	- 50.0%
Tight cover ladle	230,000	- 58.0%

In quantitive terms the covered ladle (tight cover) results in gas usage reduction of:

$$550{,}000 \times 0.58 = 320{,}000 \text{ Btu/hr}$$

At \$0.3 per therm, cost reduction = \$0.96/hr

Based on 20 % utilization, 8 hours/day, 240 days per year, the annual cost reductions:

$$0.96 \times 8 \times 240 \times 0.2 = \$370$$

It should be noted that the example is worked for one ladle only whereas generally more than one ladle is in use daily. Also size of ladle and therefore burner size will have impact on total possible savings.

COMBUSTION SYSTEMS

High efficiency burners reduce drying and preheating time which translates into increased ladle utilization and energy reduction.

Comparison between a conventional burner (high intensity) and a high efficiency burner is shown in Figure 2 and Figure 3.

Example: Time required to raise ladle refractory to 1300°F is 1 hour, using conventional burner.

Indicated time for improved burner with high efficiency characteristics, is shown on Figure 2 to be approximately 0.25 hours. With fuel usage of 1,000 cu. ft. and 400 cu. ft. respectively as indicated on Figure 3.

Thus efficiency improvement is calculated from

$$\frac{\text{Fuel usage reduction} \times 100}{\text{Original fuel usage}} = \text{percent}$$

$$\text{Therefore: } \frac{(1{,}000 - 400)\ 100}{1{,}000} = 60.0\%$$

Equivalent energy reduction for ladle preheating in previous example using 230,000 Btu/hr, the gas usage reduction is:

$$230{,}000 \times 0.60 = 138{,}000 \text{ Btu/hr.}$$

At \$0.3 per therm, the cost reduction =

$$\frac{138{,}000 \text{ Btu/hr} \times 0.3}{100{,}000 \text{ Btu/Therm}} = \$0.414/\text{hr}$$

Based on 20 % utilization, 8 hours/day, 240 days per year, the annual cost reduction is:

$0.414 x 8 x 240 x 0.2 = $160

INSULATION

Ladle insulation and covers increases heating efficiency which leads to quicker heating and thus less time for losing energy by conduction and radiation through the ladle walls. Improved wall insulation saves energy in two ways, first by reduction in pre-heat gas requirements and second by minimizing the metal temperature loss during the pour, thus lowering the initial superheat required by the melter and extending the usable pouring period of the ladle with the possibility of reducing scrap castings by pouring less cold metal.

Example of energy savings by installing 1/2 inch insulation between the 2 inch refractory and the shell. The heat lost during ladle preheating is to be calculated and compared to lining without insulation.

Area of lining 30" dia. x 30" deep = 12 sq. ft.

Heat loss through conventional lining material is calculated from

$$Q = \frac{t_1 - t_2}{R_1 + R_2} = \text{Btu/Sq.Ft/hr}$$

$$\text{Where } R = \frac{\text{Thickness of Lining}}{\text{"K" value}}$$

t_1 = hot face temperature (1300°F)

t_2 = cold face temperature (200°F)

K = thermal conductivity of lining material from Figure 4 and Figure 5

$$\text{Thus Qa (no insulation)} = \frac{(1300 - 200)}{R_1} \text{ 12 sq.ft.}$$

$$R_1 \text{ (high alumina cement)} = \frac{2.5 \text{ inches}}{K} = \frac{2.5}{6} = 0.42$$

$$Q = \frac{1100 \times 12}{0.42} = 31{,}400 \text{ Btu/hr}$$

$$\text{Qb (With Insulation)} = \frac{(1300 - 200)\ 12}{R_1 + R_2}$$

$$R_1 = \frac{2 \text{ inches}}{6} = 0.333$$

$$R_2 \text{ (ceramic fiber)} = \frac{0.5}{K} = \frac{0.5}{0.29} = 1.72$$

Note: Ceramic fiber layer assumed to have a mean temperature below 600°F.

$$Qb = \frac{1100 \times 12}{0.333 + 1.72} = 6,400 \text{ Btu/hr}$$

Reduction in heat loss = 31,400 - 6,400 = 25,000 Btu/hr

Equivalent to 79.6% savings in energy.

From previous example, net reduction in energy usage is:

31,400 Btu/hr x 0.796 = 25,000 Btu/hr

At $0.3 per therm, cost reduction

$$\frac{25,000 \times 0.3}{100,000 \text{ Btu/Therm}} = \quad \$0.075/\text{hr}$$

Based on 20% utilization, 8 hours per day, 240 days per year, annual energy cost savings is = 0.075 x 8 x 240 x 0.2 = $28.80/year.

SUMMARY (PROBABLE ENERGY SAVINGS)

The following table summarizes present and probable energy requirements for ladle heating as determined in sample calculations if all the improvements are carried out.

ITEM	BTU/HR SAVED	%SAVINGS	ANNUAL GAS THERMS	SAVINGS COST $
Covers	320,000	58.0	1,233	370
Combustion System	138,000	60.0	533	160
Insulation	25,000	79.6	96	30
EQUIPMENT TOTAL	483,000	--	1,862	$560

Actual overall energy saving between 50% and 60% is considered to be practical for the majority of ladle heating operations. Additional savings can be realized if ladle heater utilization is reduced to 15% of the typical 8 hour shift period.

ECONOMIC EVALUATION

ITEM

1. Provide insulated cover (material cost)	=	$ 500.00
2. Replace burner with 'High Efficiency' unit with gas controls	=	4,000.00
3. Add insulation to ladle lining 1/2" x 12 sq. ft. (material cost)	=	50.00
4. Labor to install cover	=	450.00
SUBTOTAL		$ 5,000.00
5. 10% Engineering cost		500.00
TOTAL		$ 5,500.00

$$\text{Payback period} = \frac{\text{Capital Investment}}{\text{Energy Savings}} = \text{years}$$

$$\text{Thus payback} = \frac{5{,}500}{560} = 9.8 \text{ years}$$

Note - installation of insulated lining is assumed to be carried out during normal reline schedule and labor cost is expensed. The above costs are "order of magnitude" only.

PART C

COKE FUEL MELTING - CUPOLA

GENERAL

Methods of melting to be analyzed in this section are:

Lined Cold Blast Cupola

Lined Cupola With 500°F Hot Blast

Water Cooled Cupola With 1,000°F Hot Blast

Divided Blast Cupola, Cold Blast

Lined Cupola, Cold Blast With 2-4% Oxygen Enrichment

COKE USAGE

The conventional cupola is a vertical shaft type furnace with refractory lining and equiped with a windbox and tuyeres for the admission of air. The sequential material charges, through the stack of the cupola, comprise alternate layers of metallics and coke with some fluxes added. The descending fuel replaces that burned from the original coke bed and maintains the height of this bed.

COKE BED CALCULATIONS

Example

Bed coke height above tuyeres is;

10.5 x sq. root of blast pressure (onces) + 6

Therefore if windbox pressure = 16 onces

Bed coke height = (10.5 x 16) + 6 = 48"

Thus the volume of bed coke required per melt campaign is obtainable by reference to Table 1. Consider above example and determine weight of coke required in initial bed as follows:

Read Table 1, for volume at 16 onz. pressure = 38.5 cu. ft., therefore at 30 lbs/cu. ft., weight of coke = 1155 lbs.

Additional coke may be required to be added to maintain bed height during initial melt period, to obtain full burning of the bed prior to the first charge of metal, also for starting the blast. Additional coke to fill the hearth up to tuyere level, must be made based on specific cupola design. Total energy required to operate the cupola, including bed coke and electric power, is to be calculated as shown on the work sheet as follows:

STANDARD CALCULATION FORMAT FOR CUPOLA ENERGY DATA

Standard 48" Lined, Cold-Blast Cupola.

Melt rate TPH. 9.0 x 2000 18,000 lbs/hr.

Metal to Coke ratio 10:1 ,Coke charged/hr 1,800 lbs.

CFM Air Reqd. 4,100 @ Blast Pressure 18 ONZ

Fan HP 50.0

Skip Loader 7.5

Dust Collector 55.0

Misc. Power 5.0

Equivalent BTU/HR $\frac{117.5 \times .746 \times 3412}{1.73}$ = 172,878

Coke Charged/HR . . . . 1800 LBS/HR

Bed Coke x 1/8 225

Equivalent BTU/HR 2,025 x 12,500 = 25,312,500

TOTAL BTU/HR = 25,713,410

AVERAGE BTU/TON OF METAL CHARGED = 2,831,700

OPERATION OF SPECIAL CUPOLAS

Comparison of current cupola operation with alternate systems, hot blast type, divided blast or oxygen enriched blast, can be made by reference to the model energy chart graphs at specific melt rate requirements.

It is assumed that the cupola melt rate, in all cases, is based on conventional practice prior to improvements.

TABLE 1. BED COKE REQUIREMENTS

NORMAL WINDBOX PRESSURE (OZ)	BED COKE ABOVE TUYERES (INCHES)	MELT DIAMETER (INCHES)	ZONE AREA (SGINS)	VOLUME COKE (CU.FT.)
7	28-34	18	254	5.0
12	36-42	23	415	10.0
14	40-46	32	804	21.4
16	42-48	42	1,385	38.5
18	45-51	48	1,809	53.4
20	47-53	72	4,071	124.9

Assumption:
Density of Cupola Coke = 30 lbs/cu.ft.

TABLE 2. CUPOLA OPERATING CHARACTERISTICS

IRON TO COKE RATIO	COKE PER TON OF MELT LB	MELTING RATE TONS PER HOUR	METAL TEMPERATURE °F	APPROXIMATE THERMAL EFF., %
12 to 1	167	16.0	2,656	46.7
11 to 1	182	15.2	2,672	43.0
10 to 1	200	14.2	2,686	39.5
9 to 1	222	13.1	2,706	36.0
8 to 1	250	12.0	2,730	32.0
7 to 1	286	10.9	2,762	28.4
6 to 1	333	9.8	2,798	27.0

LINED CUPOLA - IRON MELTING

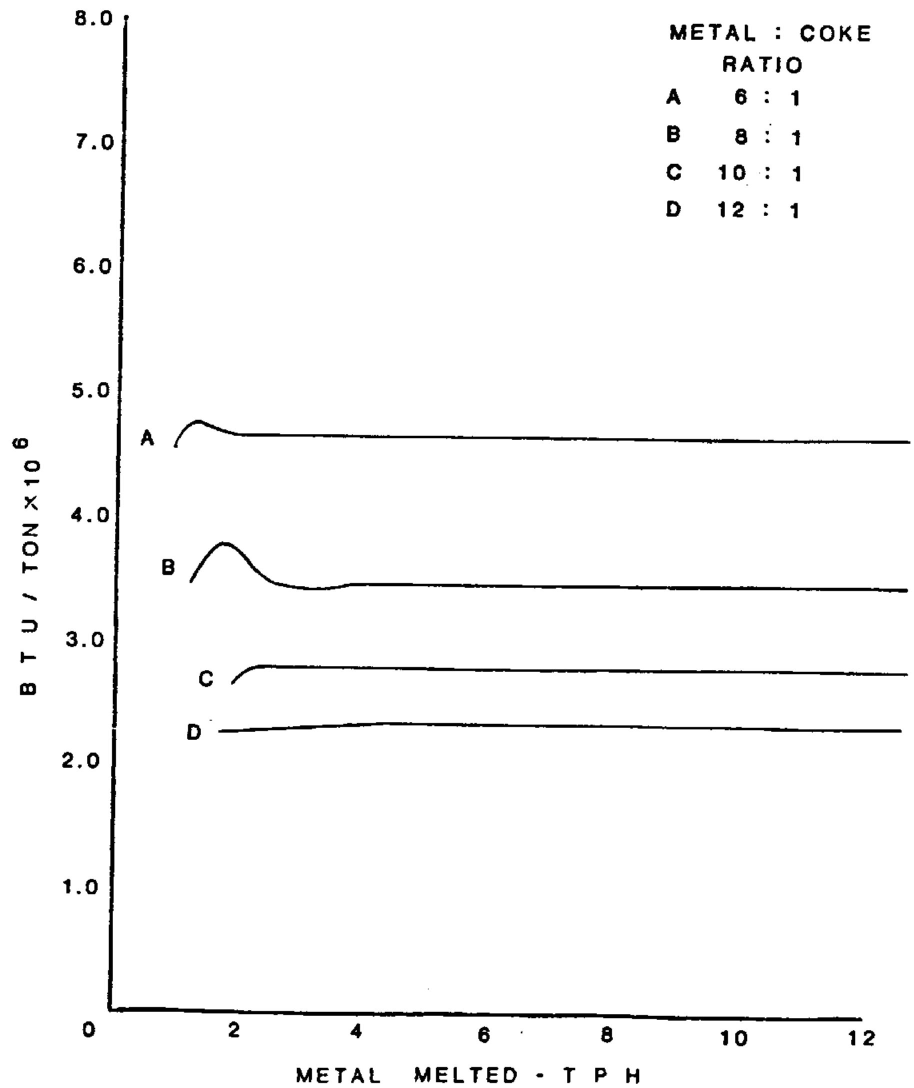


FIGURE 1

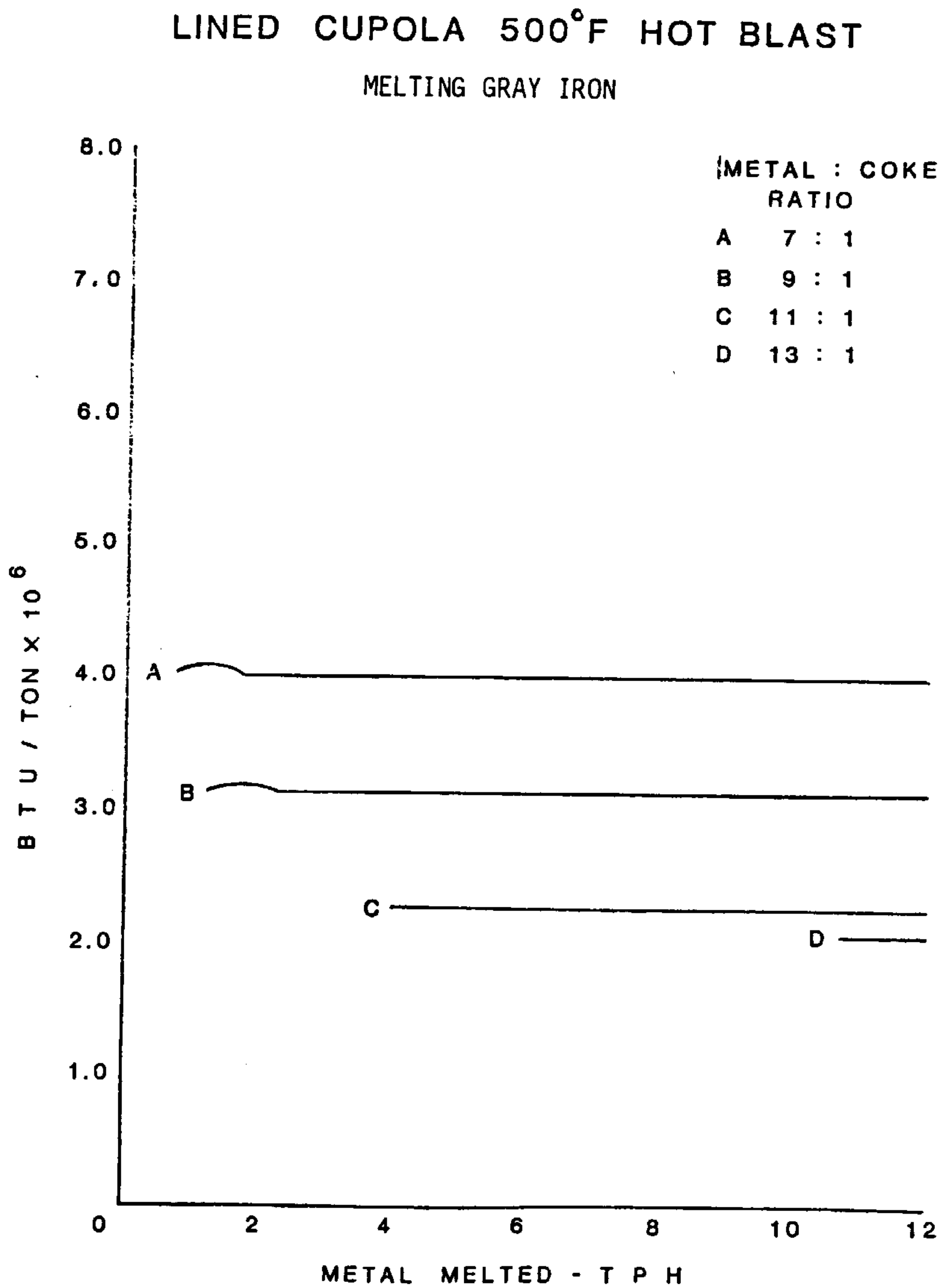

LINED CUPOLA 500°F HOT BLAST
MELTING GRAY IRON
METAL : COKE RATIO
A 7 : 1
B 9 : 1
C 11 : 1
D 13 : 1
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
2
4
6
8
10
12
B T U / TON x 10^6
METAL MELTED - T P H
A
B
C
D

FIGURE 2

LININGLESS 1000 F° HOT BLAST CUPOLA

MELTING GRAY IRON

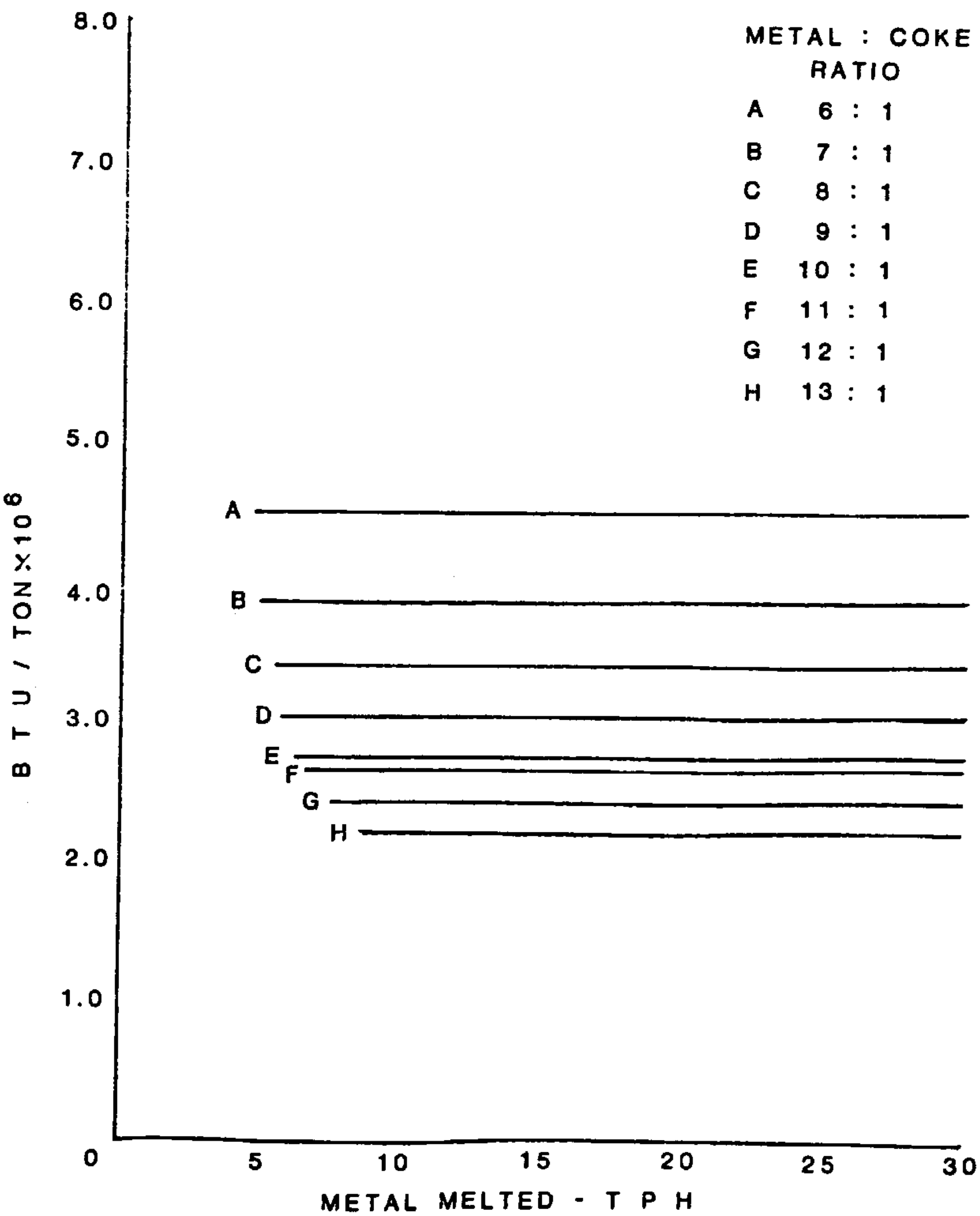


FIGURE 3

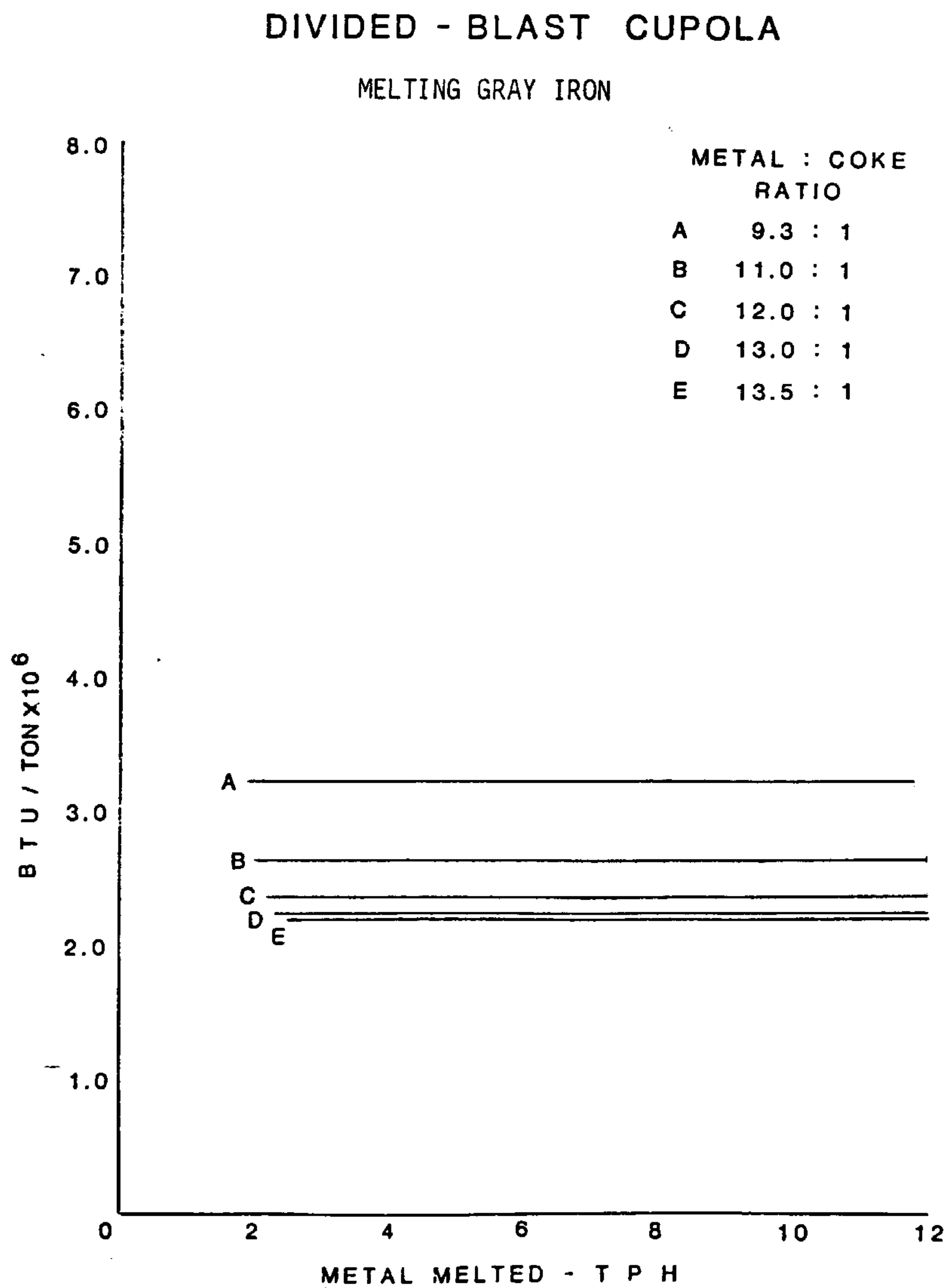

DIVIDED - BLAST CUPOLA
MELTING GRAY IRON
METAL : COKE RATIO
A 9.3 : 1
B 11.0 : 1
C 12.0 : 1
D 13.0 : 1
E 13.5 : 1
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
B T U / TON X 10^6
A
B
C
D
E
0
2
4
6
8
10
12
METAL MELTED - T P H

FIGURE 4

LINED COLD BLAST CUPOLA
WITH OXYGEN ENRICHED BLAST

MELTING GRAY IRON

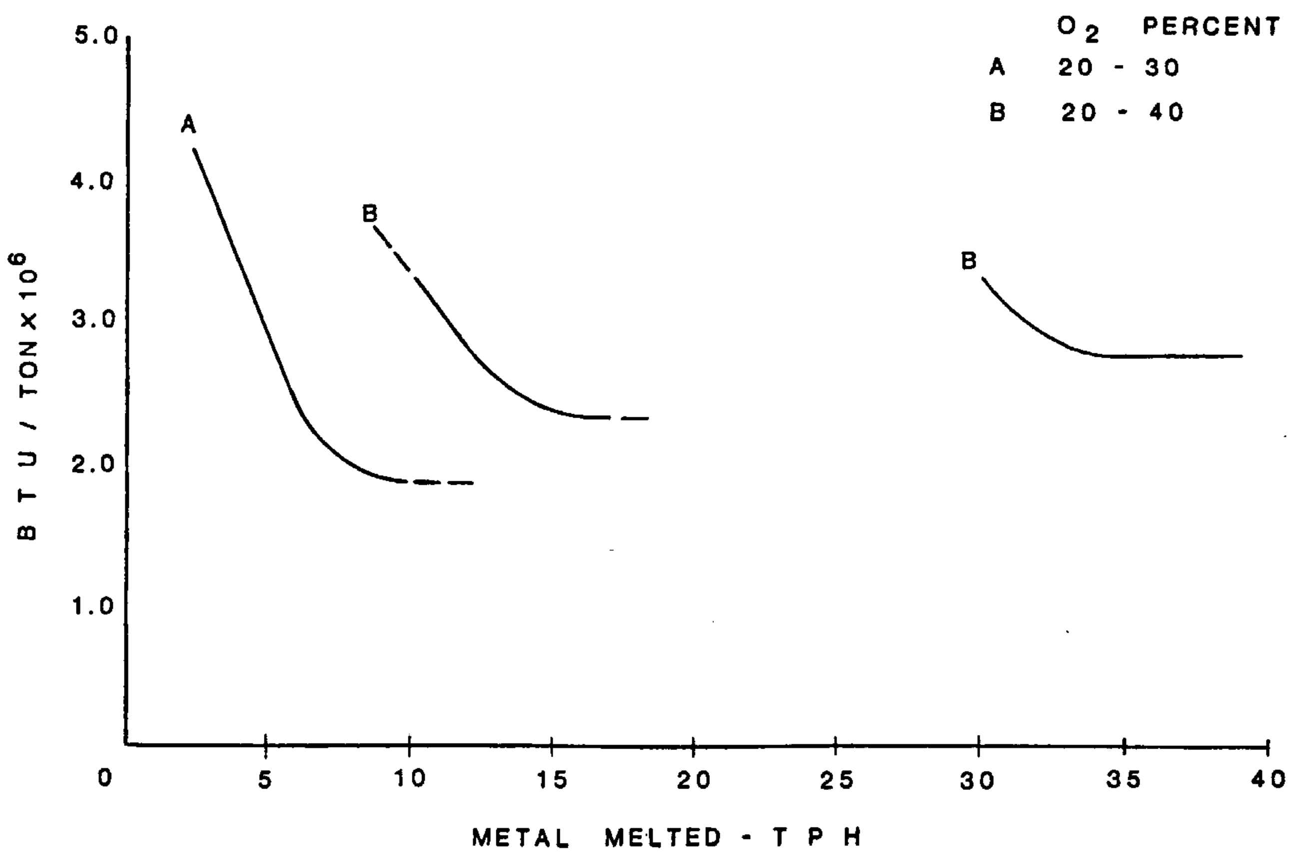


FIGURE 5

RELATIVE MELT RATE/HOUR FOR 1,000°F
HOT BLAST LINING LESS WATER-COOLED CUPOLA

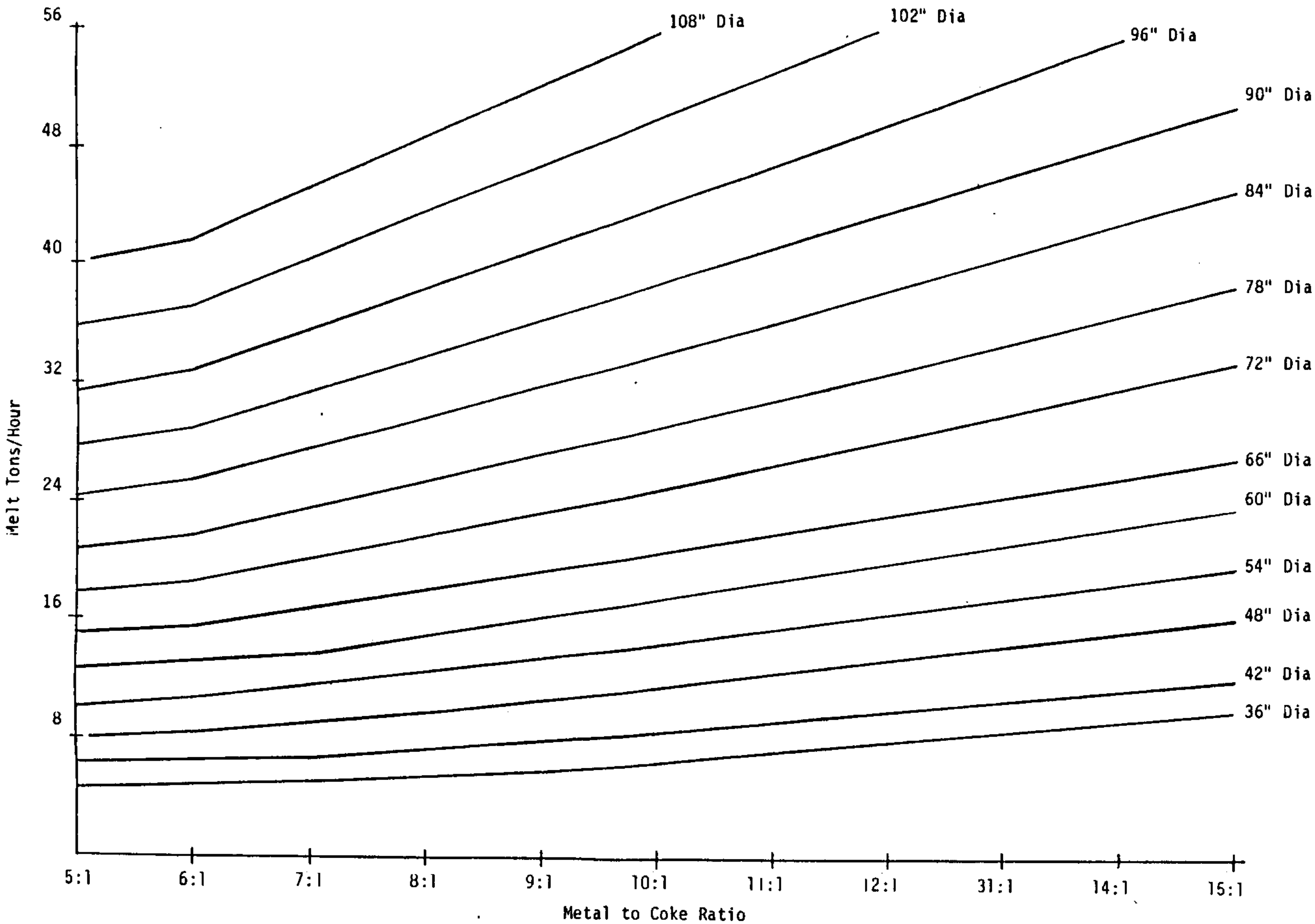
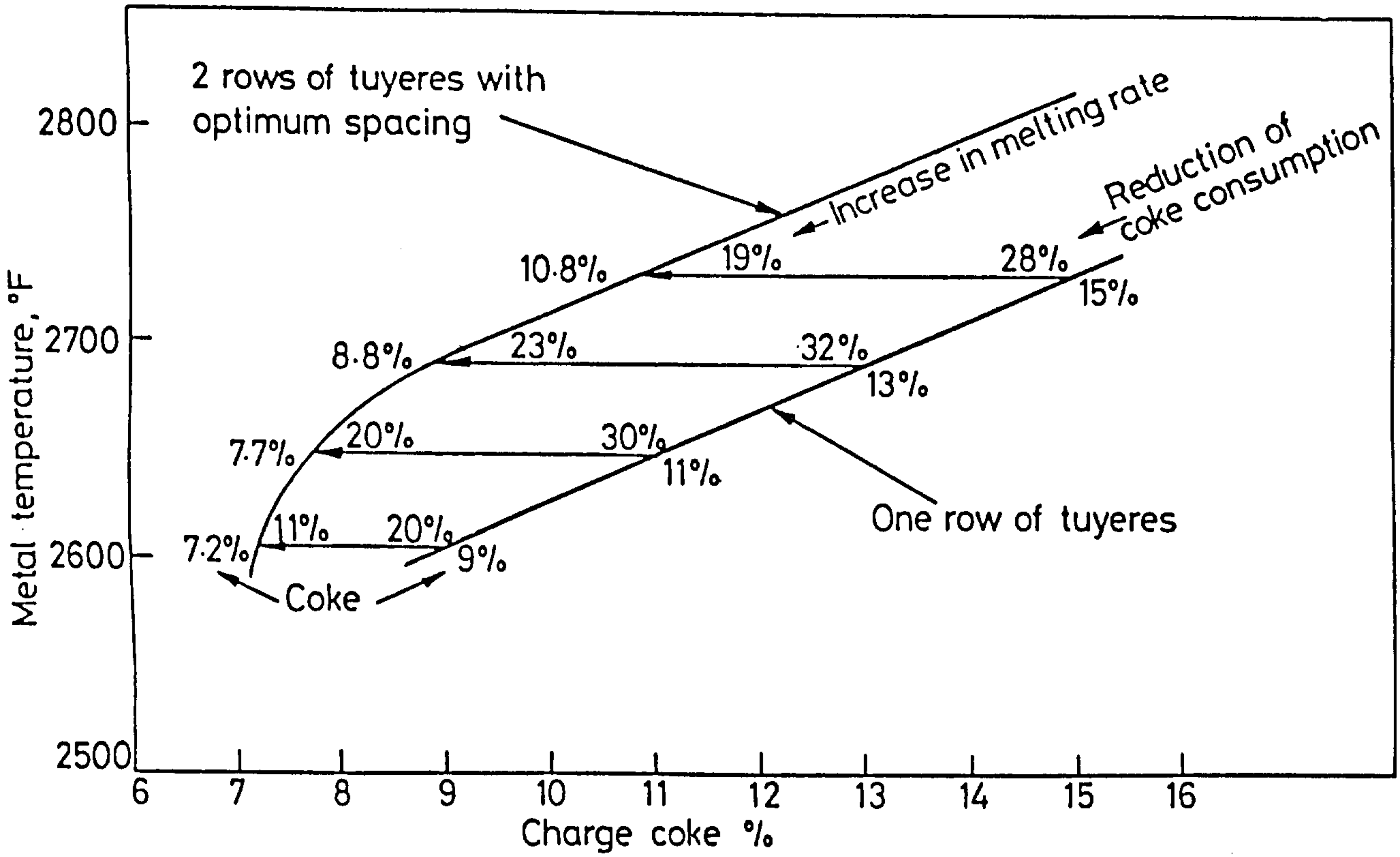


FIGURE 6

Σ K & G

FIGURE 7



Reduction of charge coke consumption and increase in melting rate by operating cupola with two rows of tuyeres with divided-blast supply (Blast rate 1600 ft³/min)

C-9

COKE TO METAL RATIO (TAP TEMPERATURES)

The range of sizes and operating recommendations for conventional cupolas has been developed over a long period of time resulting in fairly standard data (see TABLE 2). Ratio of metal weight to coke charged, excluding the bed coke, determines the melt rate and/or temperature of iron as it leaves the cupola. Higher tapping temperatures involve a penalty in coke usage and melt rate, with conventional designed cupolas.

Example

If metal is to be tapped from a cupola at 2,762°F, calculate the energy (coke) penalty compared to tap temperature of 2,686°F. From table 2, a cupola producing 10.9 tons per hour with iron to coke ratio of 7:1 for 2,762°F tap temperature, results in approximate thermal efficiency of 28.4% at 2,686°F.; the cupola would produce 14.2 tons/hour with iron to coke ratio of 10:1 and approximate thermal efficiency of 39.5%.

Thus at 7:1 ratio, coke usage = 286 lbs/ton melted

10:1 ratio coke usage = 200 lbs/ton melted

Reduction = $\overline{86}$ lbs/ton melted

∴ Penalty for 76°F super heat is equivalent to:

$86 \times 12{,}500$ BTU/lb $= 1.075 \times 10^6$ BTU/ton melted

At $0.10 per lb for coke, the cost difference

= 86 x 0.10 = $8.60 per ton melted

Annual energy reduction based on 15,000 tons per year of metal melted

$= 1.075 \times 10^6 \times 15{,}000 = \underline{16{,}125 \times 10^6 \text{ BTU}}$

Energy reduction $= \frac{86}{286} = 30.0\%$

Cost savings per year = $8.60 x 15,000 = <u>$129,000</u>

Thermal efficiency improvement = 39.5 - 28.4 = 11.1%

Note- In above example the coke bed height in each case is the same and does not effect the melting energy difference.

Tap temperature reduction may be impractical without other operational improvements such as insulation of launders, pouring ladles, etc. Control of production scheduling is required to minimize holding periods or delays prior to pour off; also, redesign of gating to enable lower casting pouring temperatures is another requirement.

SPECIAL CUPOLA MELTING CONDITIONS

To obtain increased melting or higher temperature and more efficient coke usage, refinements to the standard cupola are available.

Blast conditioning, through utilization of recuperative hot blast, can be provided using the waste heat from the cupola exhaust. Approximately 60% of cupola effluent gas is utilized as fuel to combine with combustion air for the liberation of heat in the heat exchanges.

HOT BLAST SYSTEM

Model energy usage in BTU/ton of iron melted can be determined by reference to specific charts and by projecting a point on the graph, at known metal to coke ratio, from desired melt rate in tons per hour. (Figure 1).

Value determined from the graph can be compared to proposed operation under new conditions of operation, by calculation of actual energy usage difference for requirements, as per following example.

Example

In the previous example, the metal to coke ratio in a conventional cupola is 10:1. From Fig. 1, graph line C, the energy required to melt is 2.85×10^6 BTU/ton. (Includes melt coke, bed coke and electrical energy.)

From Figure 6, for conditions of 1,000°F hot blast, a similar size 48" diameter cupola is indicated to be capable of melting 14.2 tons/hr. at 13:1 metal to coke ratio.

Thus reading energy required for 1,000°F hot blast cupola at 13:1 metal to coke ratio, from Figure 3, is:

Energy required = 2.20×10^6 BTU/ton

Reduction in energy/ton = $(2.85 - 2.20)\ 10^6$ BTU/ton = 650,000 BTU/ton

Which is equivalent to $\frac{0.65}{2.85}$ = 22.8% improvement

$\therefore$ Annual energy reduction based on 15,000 tons of metal melted per year = $\frac{650{,}000 \text{ Btu/ton melted}}{12{,}500 \text{ BTU/lb.}}$ = 52 lbs coke/ton

At \$0.10 per lb, cost reduction = 52 x 15,000 x 0.10 = <u>\$78,000 per year</u>

DIVIDED BLAST CUPOLA

Provision of two rows of tuyeres enables higher metal tapping temperatures to be obtained for a given consumption of coke, or reduction of 20 to 30 percent coke with increased melt rate of 11 to 23 percent with a given blast rate and constant tapping temperature. Comparison of thermal balances for conventional (one row of tuyeres vs. divided blast operation) is as follows:

Item	Conventional	Divided
Coke charge %	12.0	12.0
Metal temp.°F	2655	2755
Top gas composition CO_2 %	11.9	13.1
Top gas composition CO %	15.0	13.0
Combustion ratio $\frac{CO_2}{CO_2+CO} \times 100$	44.2	49.8
Top gas temp. °F	860	970

Utilization of Heat Supplied

Sensible heat in metal at Top temp. (thermal efficiency)	%	34.7	35.7
Latent heat in top gas	%	38.9	35.0
Sensible heat in top gas	%	12.8	15.1
Other losses	%	13.6	14.2
TOTAL		100.00	100.00

Example

Show reduction of charge coke consumption and increase in melting rate by operating a cupola with two rows of tuyeres at a blast rate of 1,600 cu. ft/min, compared to the cupola operating under previous example conditions. At 13:1 metal to coke ratio, the charge coke is 7.7% addition. Read Figure 7 for reduction of coke with two rows of tuyeres (divided blast) at 2,686°F metal temperature and 7.7% charge coke.

∴ From graph line (Figure 7) for 2 rows of tuyeres, the reduction of coke consumption = 30%

Thus coke savings for divided blast cupola operation,

= 2,000 x 0.077 x 0.3 = 46.2 lbs/ton of melt

@ 12,500 BTU/lb, energy saved per ton of melt = 46.2 x 12,500 = 577,500 BTU

Total energy requirements for cupola from previous example is approximately 2.20 x 10^6 BTU/ton melted at 13:1 metal to coke ratio.

Revised energy requirement; divided blast cupola, per ton $= 2.20 \times 10^6 - 577{,}500 = 1.62 \times 10^6$ BTU

By calculation, the new metal to coke ratio is equivalent to energy required at 15.8:1 metal to coke ratio or approximately 126 lbs of coke per ton of melt.

$\therefore$ Annual energy reduction based on 15,000 tons of melt required per year $= 577{,}500 \times 15{,}000 = 8662.5 \times 10^6$ BTU

Percent energy reduction $= \dfrac{577{,}500}{2.20 \times 10^6} = 26.2\%$

Cost reduction for 15,000 tons per year melt requirement

= 15,000 tons x 46.2 lbs/ton x \$0.10/lb = <u>\$69,000</u>/yr.

OXYGEN ENRICHED BLAST SYSTEM

A minimum production rate of 15 tons/day and 3 days per week is generally needed to justify the use of oxygen to gain production increase. Also no major reduction in coke usage occurs above 10 tons per hour melt rate with 2 - 3% O_2 enrichment. Savings at lower production rates are obtained as follows:

Example

Increased melting rate and/or tap temperature can be obtained by oxygen enrichment of 2 - 3%.

The total energy required can be read from graph 'A' Fig. 5 for production under 10 tons/hour.

Thus energy at 9 tons/hour metal melted $= 1.85 \times 10^6$ BTU/ton

Energy reduction compared to say a divided blast cupola (ref. Fig. 4) with metal to coke ratio of 13.5:1 (graph "E")

$$2.20 \times 10^6 - 1.85 \times 10^6 = 350{,}000 \text{ BTU/ton}$$

Percent savings $= \dfrac{350{,}000}{2.20 \times 10^6} = 16\%$

Cost reduction based on reduction of coke $= \dfrac{350{,}000}{12{,}500 \text{ Btu/lb}}$

= 28 lbs/ton melted at \$0.10 per lb, the annual savings in coke

energy for 15,000 tons melted = 15,000 x 28 x 0.10 = \$42,000/yr.

OVERALL ENERGY SAVINGS

The following table summarizes the possible cost and energy savings by improvements to the cupola operation.

ITEM	BTU/TON SAVED	ENERGY % IMPROVEMENT	ANNUAL COKE THERMS	SAVINGS COST $
Tap Temp. Reduction	1,075,000	30.0%	161,250	$ 129,000
Hot Blast System	650,000	22.8%	97,500	78,000
Divided Blast System	577,000	26.2%	86,625	69,000
Oxygen Enrichment (Not Applicable)		-	-	-
TOTAL	2,302,000		345,375	$ 276,000

Percent energy use reduction $= \frac{2,302,000}{2,857,050} = 80.5\%$

Original thermal efficiency (approx.) 28.4

Improved thermal efficiency

$$= \frac{\text{Heat in iron (approx. 405 BTU/lb.)} \times 100}{\text{Gross Energy Input}} = \frac{810,000 \times 100}{1.62 \times 10^6} = 50.0\%$$

ECONOMIC EVALUATION

The order of magnitude cost, to implement all improvements for the sample cupola considered, is used to emphasize the viability of large capital expenditures for energy conservation measures. The payback is further improved, if full tax credits are accounted for and adjustments made for impact of future energy cost.

Example

$$\text{Payback period} = \frac{\text{Capital Investment}}{\text{Energy Cost Savings/year}}$$

$$\therefore \text{Payback} = \frac{\$1,000,000}{276,000} = \underline{3.6 \text{ years}}.$$

COKE VS. ELECTRIC

COMPARATIVE ANALYSIS

To determine the best method, involves consideration of a complex interrelationship of specific foundry needs, relative to furnace operation. Energy for melting is only one aspect and not necessarily the primary factor, however, this analysis deals with differences in costs of melting due to energy only.

Based on calculated cost of energy developed elsewhere in this study, the cost of potential heat by alternate methods is summarized as follows:

Item	Foundry Coke	Electricity (Ave.)
Cost of Energy	\$167.50/net ton	\$ 0.0400/KWA
Potential Heat Content	12500 Btu/lb.	3415 Btu/KWH
Cost per million Btu	\$6.70	\$ 11.70

Energy for pre-heating, melting and superheating 1 ton of cast iron to 2,700°F.

552 Btu/lb x 2000 = 1,100,000 Btu/ton

Percent of energy requirement for each phase of the melting cycle is as follows:

	Btu/lb.
Pre-heat to melt temp.	552 Btu/lb x 65% = 358.8
Melt to liquid state	552 Btu/lb x 22% = 121.4
Super heat to 2,700°F	552 Btu/lb x 3% = 71.8%

For melting efficiencies of different types of equipment used for melting cast iron (see Figure 1.).

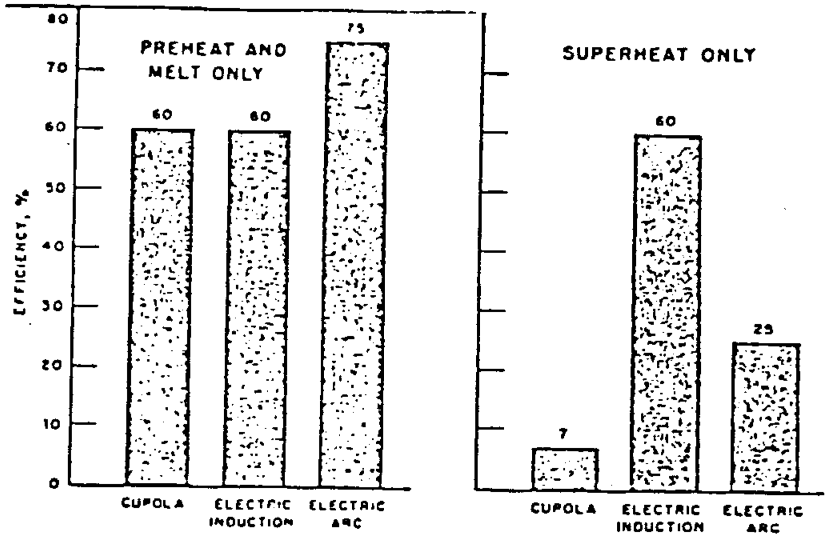


FIGURE 1. MELTING EFFICIENCIES

The following TABLE compares the three practical melting methods with respect to energy economics.

ITEM	CUPOLA	ELECT. INDUCTION	ELECT. ARC.
Cost to preheat	$ 8.01	$ 13.99	$ 11.19
Cost to melt	2.71	4.73	3.79
Cost to superheat	13.74	2.80	6.72
TOTAL	$ 24.46	$ 21.52	$ 21.70
BTU's required x 10^6	3.65	1.84	1.85

Example

Cost to pre-heat one ton of metal by cupola to melt temperature;

$$\text{Btu required} = \frac{35.8 \text{ Btu/lb} \times 2000 \text{ lbs}}{60\% \text{ Efficiency}} = \frac{0.72 \times 10^6}{0.60} = 1.196 \times 10^6$$

Cost of energy @ \$6.70 /million Btu = 1.196 x 6.70 = \$8.01

On the basis of this analysis, the electric induction furnace is more energy efficient. However, the analysis can be applied to any combination of melting methods to obtain the most energy cost effective results (See Figure 2).

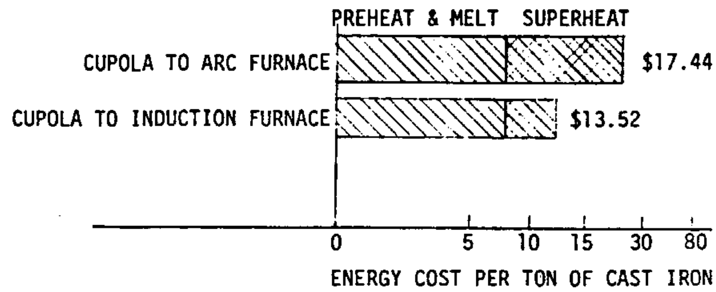


FIGURE 2

Subject to the practical feasibility of these combinations and not accounting for other capital or operating costs, the cupola to induction furnace approach at $13.52 per ton melted is the least cost. Btu's required by this method based on previous calculations are:

Cupola	1.60×10^6
Induction	0.24×10^6
TOTAL	1.84×10^6 Btu/ton

PART D

GAS-FIRED CHARGE PREHEATING

GENERAL

Furnace charge preheating, up to 1,000°F for iron, results in energy and cost reductions of up to 25%.

This section deals with charge preheating by;

- Gas-fired burner units.
- Oxygen assisted burners.

Diagrams and tables indicate typical data and performance for equipment commercially available. Similar information should be reviewed from alternate sources prior to actual energy audit work being carried out.

Example

Required, scrap preheat temperature of 1,000°F for batches of one ton size to be charged to an electric melting unit, operating 8 hours per day, 240 days per year at annual rate of say 3,000 tons of gray iron.

Increased melt production percentage is obtained by reference to Figure 1, reading for 'iron' at 1,000°F scrap temperature.

@ 1,000°F, resulting increase = 30%

Equivalent Energy Requirements:

Natural Gas-Fired Unit:

@ 1,000°F = 600 cu. ft/ton = 600,000 Btu (from Table 1)

Thus: Cost @ $0.3/Therm x 6 Therms = $1.80/ton

Electrical Energy Usage Reduction

@ 1,000°F = 117 kW/ton (from Table 1)

Thus: Cost @ $0.042 per kW = $4.91/ton

Net cost savings = (4.91 - 1.80) = $3.11 per ton

Annual cost reduction = 3,000 x 3.11 = $9,330

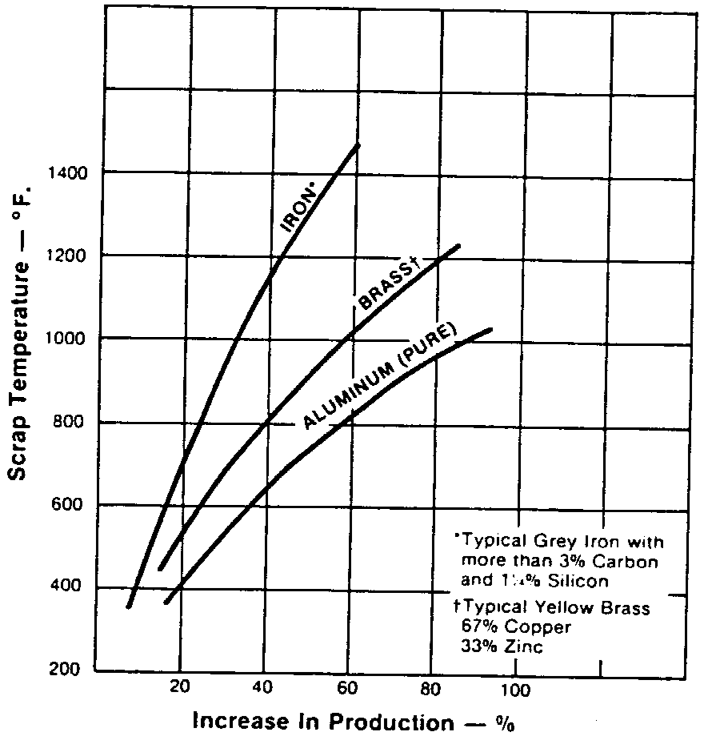


FIGURE 1. INCREASED MELT PRODUCTION

TABLE 1

Furnace Charge Preheating Energy Comparison for Arc and Induction Melting of Iron, Aluminum and Brass

Efficiency Basis: Induction Furnace @ 70%/Fuel (Gas, Propane, Oil @ 47% to 93%, depending on Temperature).

Preheat Temp. °F.	KW Usage per Ton Cold Melt			Venetta Usage per Ton/CF Natural Gas @ 1000 BTU/Cu. Ft.			Venetta Usage per Ton/Gal. Propane @ 91,735 BTU/Gal.			Venetta Usage per Ton/Gal. #1 or #2 Fuel Oil @ 138,000 BTU/Gal.		
	Iron	Alum.	Brass	Iron	Alum.	Brass	Iron	Alum	Brass	Iron	Alum.	Brass
500	59	101	44	150	256	105	1.64	2.8	1.14	1.1	1.9	.8
600	70	121	53	216	365	151	2.4	4.0	1.65	1.6	2.6	1.1
700	82	141	62	276	469	193	3.0	5.0	2.1	2.0	3.4	1.4
800	94	161	70	372	640	261	4.1	7.0	2.8	2.7	4.6	1.9
900	106	181	79	480	808	332	5.2	8.8	3.6	3.5	5.9	2.4
1000	117	201	89	600	1012	417	6.5	11.0	4.5	4.3	7.3	3.0
1100	129			792			8.6			5.7		
1200	141			1008			11.0			7.3		
1300	152			1320			14.4			9.6		
1400	164			1680			18.3			12.2		

OXYGEN-FUEL ASSISTED MELTING

Oxy-fuel assisted melting involves supplying additional heat energy during melt down by introducing oxygen as a fuel to supplement or replace the electrical power input to the furnace. Oxy-fuel assisted melting practice has been applied successfully to most nonferrous and ferrous metals with the exception of brass which exhibits high zinc loss. Suitable stoichiometric firing rates are chosen for each metal to minimize oxidation.

> Note: Wellman Alloys Limited of England used oxy-fuel (propane) burner - melting rate increased by 80% - energy savings in excess of 15%.

Example

Data based on various induction furnaces incorporating oxy-fuel indicates average of 26% improvement in power input, reference Table 2.

TABLE 2. OXY-FUEL ASSISTED MELTING IN INDUCTION FURNACES

Data Obtained From Various Induction Furnaces Incorporating Oxy-Fuel						Melt Down Time Tap to Tap, Min.			Furnace Electrical Power Input, kwhr/ton			Melting Rates, ton/hr		
Case No.	Furnace Capacity Ton (kg)	Furnace Rating kw	Material Melted	Fuel	Btu/ton x 10⁶ (kwh/ton)	Normal	Assisted	Improvement, %	Normal	Assisted	Improvement, %	Normal	Assisted	Improvement, %
1	.3 (305)	200	Ductile Iron	Propane	.775 (227)	73	51	30	897	628	30	.248	.354	44
2	.5 (509)	150	Ni Cr Alloy	Propane	.60 (176)	150	95	36	1040	720	31	.20	.316	58
3	1.0 (1018)	300	Carbon Steel	Propane	.3175 (93)	150	105	30	815	680	17	.42	.60	43
4*	1.0 (1018)	300	Ni Cr Alloy	Propane	.625 (183)	184	97	47	863	500	42	.325	.612	88
5	1.0 (1018)	600	Ni Cr Alloy	Butane	.592 (173)	90	60	33	733	630	14	.68	.89	31
6	2.0 (2036)	600	Alloy Steel	Nat. Gas	.503 (147)	175	135	23	778	610	22	.67	1.0	49
7	3.0 (3054)	800	Gray Iron	Propane	.730 (214)	190	125	34	770	525	32	.632	.976	54
8	3.0 (3054)	800	Grey Iron	Propane	.297 (87)	95	77	38	680	471	19	.840	1.384	62
						Average Improvement		34.5	Average Improvement		26	Average Improvement		48.5

*Case 4: Figures and Results are for Flat-Bath-only. Courtesy Wellman Alloys Ltd., Amblecote, Stourbridge, West Midlands, England.

Extracted from Foundry M & T MPS - March 1978
by J. Allread / Grede Foundries, Milwaukee

Example

Alloy steel melted in 2.0 ton capacity, 600 kW rating furnace indicated 32% power reduction:

$$\text{Power improvement} = \frac{778 - 610}{778} = 22.0\%$$

Reduction in electricity = 168 kWH/ton
= 573,200 Btu/ton

Electric cost reduction @ \$0.042/kW = 168 x 0.042

= $\underline{\$7.05/\text{ton}}$

Added Natural Gas usage = 0.503×10^6 Btu/ton

$$\text{Therms} = \frac{0.503 \times 10^6}{100{,}000 \text{ Btu/Therms}}$$

Natural Gas cost addition @ \$0.3/Therms = $\underline{\$1.51/\text{ton}}$

Annual cost reduction based on 3,000 tons melted per year
= (7.05 - 1.51) 3,000 = $\underline{\$16,660}$.

SUMMARY

ITEM	BTU/TON SAVED	THERMAL EFFICIENCY	ANNUAL SAVINGS	
			THERMS	COST
CHARGE PREHEATER	(200,000)	-	(6,000)	\$ 9,330
OXY-FUEL ASSIST.	70,000	-	2,100	16,600
TOTAL	(130,000)	-	(3,900)	\$ 25,930

ECONOMIC EVALUATION

1. Charge preheater 1 ton capacity to operate at 1,000°F.		\$55,000
2. Oxy-fuel burner system.		23,000
3. Installation at 25%		20,000
	Subtotal	\$98,000
4. 10% Engineering		9,800
	Total	\$107,800

$$\text{Payback period} = \frac{\text{Capital Expenditure}}{\text{Cost Reduction/Yr.}} = \text{Years}$$

$$\text{Payback} = \frac{107{,}800}{25{,}930} = 4.15 \text{ Years}$$

PART E

ENERGY SAVING CHECK LIST

Many energy saving opportunities exist in all foundries that can be instituted immediately with out requiring large capital equipment investments. The checklist that follows presents these no cost/low cost energy saving ideas together with suggestion modifications and changes that will require medium to major captial investements:

	APPLIES	DOES NOT APPLY	COMMENTS
INFILTRATION Infiltration--Infiltration of cold air into the plant through cracks, openings, gaps around doors and windows, etc., increases the building's heat load and may be responsible for 20 to 25 percent of the yearly space-heating energy consumption. This waste can be eliminated, and an additional saving in heating realized, by taking the following steps: __1. Replace broken or cracked window panes. __2. Caulk cracks around window and door frames. __3. Weatherstrip windows and doors. __4. Close windows while the building is being heated. __5. Check sealing gaskets and latches for all operable windows to see that they are working properly. __6. Close all rolling-type doors when they are not being used. __7. Eliminate unnecessary windows and skylights. Heating, Ventilating, and Air-Conditioning (HVAC) Systems--HVAC systems have a significant impact on the plant's total energy consumption. These changes in operational routine can cut HVAC energy use 5 to 15 percent: __1. Establish minimum temperature levels for the heating season and maximum levels for the cooling season. Establishing these levels requires consideration of occupied and unoccupied periods. __2. Repair or replace all damaged or defective thermostats or control equipment; calibrate as necessary. __3. Mount thermostats on inside walls and columns only. __4. Lock all thermostats to prevent unauthorized personnel from tampering with them. __5. Eliminate the use of mechanical cooling when the plant is unoccupied. Turn off heat or maintain a 50 F minimum in unoccupied areas. __6. Inspect all outside air dampers to ensure that they establish an air-tight fit when closed. __7. Establish startup and shutoff times for HVAC systems. __8. Shut off or adjust HVAC systems during weekends and holidays. __9. Minimize outdoor air intake.			

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	APPLIES	DOES NOT APPLY	COMMENTS

Makeup-Air Units--Whenever air must be heated, inefficiencies are probable. The following modifications to makeup-air units can help conserve energy:

__1. Adjust burners for proper flame patterns.
__2. Clean burner nozzles periodically to remove mineral deposits and corrosion buildup.
__3. Observe the fire when the unit shuts down. A fire that does not cut off immediately could indicate a faulty control valve. Repair or replace the control valve as necessary.
__4. Keep all heat-exchanger surfaces clean.
__5. Inspect casings for air leaks. Seal them as necessary.
__6. Clean or replace air filters regularly.
__7. Keep fan blades clean.
__8. Inspect and lubricate motor bearing regularly.
__9. Inspect fan inlets and discharge screens to keep them free of dirt and debris at all times.

Insulation--Transmission heat losses and gains through walls, glass, roof, floor, etc., can be controlled with adequate insulation. The savings depend on the loss reductions achieved. A 5 to 10 percent saving is possible.

Lighting--Lighting represents a major portion of electrical energy use. A reasonable effort should be made to use only the amount of lighting necessary for safety and efficiency. Taking the following steps could lower plant electrical energy consumption approximately 5 to 15 percent:

__1. Use daylight for illumination when possible. Turn off lights when sufficient daylight is available.
__2. Turn off lights at night and in unoccupied areas during the day.
__3. Install simple timers on light switches throughout the plant, including in offices.
__4. Keep lighting equipment clean and in good working order.
__5. Replace burned out or darkened lamps and clean all fixtures.
__6. Increase the light-reflective quality of walls and ceilings with light colors. Such improvements may permit additional lighting reductions.

Boilers--In any boiler operation, the main source of energy waste is inefficient combustion. A 10 to 25 percent energy saving is possible by reularly following these simple checks and guidelines:

__1. Inspect boilers for scale deposits.
__2. Keep all heat-transfer surfaces as clean as possible to reduce temperature differences.
__3. Follow the boiler manufacturer's recommendations.
__4. Follow the feedwater treatment and blowdown procedures recommended by the supplier. This measure will save fuel by minimizing scale formation.
__5. Inspect door seals and other seal gaskets. Leaking gaskets waste fuel; doors may be deformed.
__6. Check boiler stack temperature. If it is too high (more than 150 to 200 deg F above steam temperature), clean the tubes and adjust the burner.

	APPLIES	DOES NOT APPLY	COMMENTS

__7. Adjust the burner so that the stacks are free of haze.
__8. Collect and analyze flue gas samples regularly to determine if combustion is efficient.
__9. Minimize the amount of excess air supplied for combustion.
__10. Operate only one boiler unless it cannot supply the load.
__11. Prevent short-cycle firing.

Steam Lines and Traps--Whether small or large, the leaks in steam piping, fittings, valves, and traps add up and can waste large amounts of energy. A detailed survey of all such piping should be made weekly or monthly and the following steps should be taken:
__1. Repair or replace defective or missing insulation.
__2. Inspect steam traps and replace those that are worn, inoperative, or improperly sized.
__3. Inspect pressure-reducing and regulating valves and their related equipment. Adjust, repair, or replace as necessary.
__4. Check pressure gauges and thermometers for recording accuracy.

Fans, Pumps, and Motors--Proper maintenance of fans, pumps, and motors can significantly improve their operational efficiency. The following steps can save energy at almost no cost:

Fans:
__1. Clean the blades.
__2. Inspect and lubricate bearings regularly.
__3. Inspect belts for proper tension.
__4. Keep inlet and discharge screens free of dirt and debris.

Pumps:
__1. Check packings for wear. Bad packings waste water and erode the shaft.
__2. Inspect bearings and belts regularly.

Motors:
__1. Keep motors clean.
__2. Prevent overvoltage and undervoltage.
__3. Eliminate excessive vibration.
__4. Correct loose connections, bad contacts, belts, pulleys, bearings, etc.
__5. Check for overheating and provide adequate ventilation.
__6. Prevent imbalance in power phase sources. This condition can cause inefficient motor operation.

Domestic Hot and Cold Water--Following these guidelines can maximize the efficiency of domestic water use:
__1. Inspect the water supply system and repair leaks, especially faucet leaks.
__2. Inspect insulation on storage tanks and piping. Repair as needed.
__3. Turn off the pump when the building is unoccupied, if hot water is distributed by forced circulation.
__4. Inspect and test hot-water controls. Regulate, repair, or replace as necessary.
__5. Disconnect all refrigerated water fountains, if acceptable to building occupants.

Compressed Air Systems	APPLIES	DOES NOT APPLY	COMMENTS
__1. Install either solenoid valves or remote operated valves on assembly line air mains to eliminate normal or accidental air leaks during non-operating hours.			
__2. Avoid utilizing expensive city water for a once through compressor cooling system. Instead, investigate recycling cooling water through a cooling tower.			
__3. Investigate utilizing waste air compressor aftercooler cooling water (95-115°F.) as boiler make up. This both saves the energy that would be required to heat city water from 55° to 95° and reduces the waste water discharged to city sewers with a resultant sewer charge reduction. As a rule of thumb, this will result in a 2 gallon fuel oil saving per 1000 gallons of make up water.			
__4. Install solenoid valves on all machine air supply lines to limit air use to actual machine operating periods.			
__5. If large quantities of low pressure compressed air are required, consider installing a separate low pressure compressor rather than reducing from the main plant supply.			
__6. Be sure the compressed air intake is in a cool location. Every 5°F. drop in intake air temperature results in a 1% increase in compressed air volume for the same compressor horsepower requirements.			
__7. Extra air receivers at points of high periodic air demand may permit operation without extra air compressor capacity.			
__8. Keep compressor valves in good condition for maximum efficiency (worn valves can easily reduce compressor efficiency 50%). Many compressor manufacturers recommend removal and inspection every 6 months.			
__9. Match compressor pressure to actual system requirements. Operating a compressed air system at higher than requiered pressure results in higher compressor maintenance and reduced efficiency, as well as increased operating costs. Most air tools are designed to operate with 90 PSI at the tool. Higher pressures result in increased maintenance and shorter tool life expectancy. Typically, a 10% increase in pressure will reduce tool life about 14%.			
__10. Size air hoses for minimal pressure drop to air tools. For instance, a tool designed to operate on 90 PSI will operate on 80 PSI, but at a 15% reduction in production.			
__11. Consider the installation of double acting water cooled piston compressors rather than rotary screw compressors if the compressor will be operating at partial load much of the time. A double acting water cooled piston compressor requires as little as 5-7% of full load horsepower when unloaded, while a rotary screw compressor can require as much as 60-75% of full load horsepower when unloaded.			

	APPLIES	DOES NOT APPLY	COMMENTS

__12. Locate and repair all piping leaks. Typically, many manufacturing plants lose about 10% of their compressed air through leaks, usually from loose pipe fittings, valve packing, shut off valves, worn out filters-regulators-lubricators, quick couplers, and unused air tools. A 1/16" leak can waste 6.5 cfm, and in addition to wasting compressor horsepower, will cost @ $8.00 per month. The hundreds of leaks in many industrial air systems can represent a tremendous energy waste.

__13. Be careful to size compressor capacity fairly closely to load, since a compressor's efficiency is highest at full load.

__14. Consider the installation of several smaller compressors rather than one large unit. Sequential operation will enable each compressor to operate at full load.

__15. Prohibit all use of compressed air operated fans or compressed air hoses for personal cooling.

__16. Remember that it requires about 1 horsepower to produce 5 CFM @ 100 PSI while a 1 horsepower vane type air motor requires about 25 CFM @ 90 PSI. Investigate replacing high usage air motors with electric motors where practical.

__17. Consider using solenoid valves to cycle punch press blow off nozzles for only a short interval. Many blow off nozzles have a 1/8" orifice and, if operated continuously, will consume about 25 CFM @ 100 PSI (the equivalent of 5 HP compressor).

__18. Consider reducing the operating speed/pressure on air operated paint pumps and paint agitators during off-shift hours. Depending on pigmentation and metallic content it may even be possible to stop all agitation or circulation of some enamels or lacquers during off hours.

__19. In addition to poor partial load mechanical efficiency, induction type compressor motors have extremely poor power factors at reduced outputs. For instance, a 250 HP induction motor has a .87 PF at full load and a .55 PF at 1/4 load. Significant low load operation can drastically raise utility power factor charges.

__20. For highest efficiency, be sure air tools are kept in good repair and are not excessively worn. For instance, a sand blast nozzle worn from 5/16" to a new diameter of 3/8" would consume an additional 65-70 CFM.

__21. Minimize low load compressor operation. If air demand is less than 50% of compressor capacity, consider converting smaller compressors from constant speed operation to start/stop operation.

__22. Install timers on desiccant type compressed air dryers to match dryer recharging cycles to actual system requirements.

__23. Match compressor operation to building hours. A time switch can permit close control of compressor hours and permit shut down of high unloaded horsepower compressors during meal breaks or shift changes.

Welding Operations	APPLIES	DOES NOT APPLY	COMMENTS
__1. Investigate converting heating equipment fuel from acetylene, natural gas, or propane to methylacetylene propadiene, stabilized (MAPP). This gas may reuslt in the improved performance, higher cutting speeds and reduced oxygen consumption.			
__2. If product design is applicable, consider utilizing seam welding (RSEW) instead of coated electrode metal arc welding (SMAW), metallic inert-gas welding (GMAW), or submerged arc welding (SAW). Since high frequency seam welding only heats the actual welding zone, distortion is minimized. The process is also less energy intensive than most other applicable welding processes.			
__3. Consider utilizing electronic precipitators to "scrub" welding exhaust fumes and thereby eliminate building exhaust with its attendant heat loss.			
__4. Install solenoid valves on welder or water cooled torch supply lines to limit cooling water flow to actual welder operating periods.			
__5. Consider the installation of smoke detectors to control welding exhaust fans.			
__6. Investigate inerta welding for uniform tubular or solid sections and similar shapes. Inerta welding can often replace alternative welding methods with their related preparatory machining operation.			
__7. Investigate using bag type dust collectors/filters to reduce building exhaust.			
__8. If welding shop workload varies widely, investigate ordering any new transformer type welders with built-in power factor correcting capacitors.			
__9. If oxy-acetylene welding/cutting torches are frequently used throughout the day, consider installing weight actuated automatic torch valves. This should help insure that an unused torch is turned off when it is hung up.			
__10. Investigate the installation of automatic cutting torches, which normally operate at maximum speed, thus yielding maximum cutting for minimum gas consumption. Their cutting speed and accuracy can often replace more energy intensive alternative manufacturing methods.			
__11. Be sure gas welding equipment connections and hoses are tight. Leaks both waste expensive gas and are fire hazards.			
__12. Investigate using high frequency induction heating for brazing operations instead of hand-held torch or a furnace.			
__13. Consider operating automatic cutting torches on natural gas or propane instead of acetylene. Acetylene has a higher flame temperature than normally required for steel cutting.			
__14. Consider using hot air instead of direct gas flame soldering torches. Since hot air is supplied at lower temperatures, it conserves energy and improves product apperance, as well as reducing fire hazards.			
__15. Replace continuous pilot lights for gas welding torches with conventional flint lighters.			

	APPLIES	DOES NOT APPLY	COMMENTS

_16. Be careful to avoid over-welding, either during design or manufacture.

_17. Use flame gouging instead of chipping hammers to remove tack welds, full welds, defects, blow holes, or sand inclusions.

_18. Consider using flame deseaming or scarfing instead of chipping hammers to remove cracks, seams, scabs, and crowsfeet. Hot scarfing can clean up forgings without the cooling and reheating required by chipping.

_19. In general, transformer type arc welders are more energy efficient than motor-generator welders. At full rated load, transformer type welders will consume slightly less power than a comparable motor-generator welder. At partial or no load, however, motor generator efficiency and power factor drop appreciably.

_20. Motor generator welders are valuable where ripple-free DC is required from single phase power. A transformer-rectifier welder cannot normally deliver well filtered DC from single phase power.

_21. Investigate "stack cutting" with automatic cutting torches. In many cases, a thicker cut uses proportionately less oxygen per piece than a thinner cut. Cutting accuracy is a maximum below 2" total thickness and gradually deteriorates until the normal maximum cutting thickness of 6" is attained.

_22. Shut down transformer type and motor-generator arc welders when not in use and during breaks and lunch. Savings will be minimal with transformer type welders but will become increasingly significant when motor-generator welders are stopped.

_23. Be sure unused automatic torches are turned off when not in use. Avoid excessive idle time.

Process and Manufacturing Operations

_1. Evaluate all machine tool purchases carefully for operating efficiency. In some cases, an alternative manufacturing method may result in lower energy usage per piece.

_2. Consider installing electrostatic precipitators to minimize dust or particle exhaust, such as from welding operations.

_3. Investigate installing smoke detectors to operate exhaust fans.

_4. Interlock process ventilation equipment with the equipment it serves.

_5. Replace simplex or duplex steam pumps with motor driven pumps where feasible.

_6. Install timers on punch presses, press brakes, and hydraulic pressses to shut down equipment if left idling for more than 10-12 minutes.

_7. Install solenoid valves on all machine air supply lines to limit air use to machine operating periods.

_8. Investigate using mechanical methods, such as a cam or solenoid to eject punch press parts instead of using compressed air.

_9. Install either automatic doors or insulated flaps on conveyor type heat treating ovens to reduce heat loss.

	APPLIES	DOES NOT APPLY	COMMENTS

__10. Install solenoid valves on all water cooled equipment water lines to minimize water leakage.

__11. Redesign processes to eliminate process exhaust ventilation.

__12. Investigate the installation of reflecting shielding or thermal barriers around heat treating equipment to minimize cooling load on adjacent areas, particularly in metallurgical laboratories.

__13. All water pumping equipment will have to operate at less than full design flow, consider the installation of variable speed pumps to minimize reduced flow power consumption.

__14. Avoid severely oversizing production equipment. An oversized tool is normally heavier and requires more power than a smaller, correctly sized tool.

__15. Operate air tools on correct pressure. Most air tools are designed to operate on 90 PSI. Tool operation on lower pressures reduces output, while only a 10 pound pressure increase results in a 14% tool life expectancy reduction.

__16. Meter unusual gas or process chemical requirements. "Billing" a department for actual consumption can often result in phenomonal consumption reductions.

__17. Modify product test or analysis procedures to avoid high energy consumption tests. For instance, minimize test time on engine operated equipment.

__18. Investigate the feasibility of operating production machinery at 100% load for one shift rather than at partial load for two shifts. For instance, careful scheduling of vapor degreaser opeation may permit full load operation for fewer hours.

__19. Attempt to reduce machine idle time as much as feasible to maintain high power factors.

__20. Assign specific plant personnel to be sure all production equipment is shut down after shift and during breaks and lunch.

__21. Operate melt furnace exhausts only during furnace charging or fluxing if feasible.

__22. Shut down process ventilation, building exhaust, and dust collection during breaks and lunch.

__23. If heat treating ovens are not required for immediate use, energy can be saved by reverting to a reduced temperature condition. Investigate constructing a cool down/reheat time chart for various furnace temperature. This will enable operating personnel to easily reduce furnace temperatures and still be able to have the furnace up to heat by the desired time.

__24. Consider operating heat treating ovens 24 hours/day to make maximum usage of energy.

__25. Use fixed cycle times for heat treating/annealing operations. Many actual oven times are far longer than actually required, with a resulting energy waste.

__26. Operate chip conveyors only when needed, not continuously.

	APPLIES	DOES NOT APPLY	COMMENTS

__27. Avoid partial heat treating furnace loads.

__28. Shift or combine operations for both reduced building hours and improved machine utilization.

__29. Minimize leaks and overflow from heated process tanks.

Material Handling and Transportation Systems

__1. Install "bump through" doors in fork lift areas to reduce open door time.

__2. Install a flexible covering, such as rubber or canvas strip, over scrap conveyor openings in building walls.

__3. Shrouds should be used in all dock doors when possible. Investigate using air curtain fans if shrouds are not available.

__4. Investigate installation of "air pallets". In some cases, they can offer energy reductions compared to lift trucks, particularly where an oddly shaped work piece must be moved short distances at slow speeds.

__5. Be sure fork lift air cleaners are clean. Some high dust locations may require centrifugal pre-cleaners to prolong filter element life.

__6. Be sure to purchase fork lift fuel that meets the manufacturers standards. Bargain fuel can actually reduce operating efficiency.

__7. In a large operation, consider the installation of two-way radio equipment on material handling equipment to reduce the number of empty return trips. Try to schedule several moves for fork lifts in an area to maximize productivity.

__8. Consider purchasing diesel fueled fork lifts. Their reduced fuel consumption and lower maintenance should result in substantial savings over gasoline or propane lifts.

__9. Investigate replacing internal combustion fork lifts with electric fork lifts. In many cases, operating costs (and energy consumption) will be lower. In some cases maintenace costs may drop up to 30%. Electric trucks also have lower downtime, are non-polluting, and are quieter.

__10. Consider installing electrical hoists rather than air operated hoists since a "1 horsepower" air hoist requires about 5 compressor horsepower, while a "1 horsepower" electric hoist requires only 1 horsepower.

__11. Replace old, out-moded (and inefficient) motor-generator electric fork lift battery chargers with new, solid state, power factor corrected high efficiency battery chargers.

__12. Avoid pushing loads. Though this only wastes fuel and wears clutches with an engine operated truck, it can severely damage a battery operated lift truck's drive motor.

__13. Install overspeed governors on all internal combustion material handling equipment, particularly fork lifts, to eliminate empolyee hot rodding.

__14. Investigate fork lift records or contact manufacturers to discover the best fork lift fuel consumption. Log all machine fuel to determine operator errors or machine deterioration.

	APPLIES	DOES NOT APPLY	COMMENTS

__15. Be careful not to overfill fork lift fuel tanks. Spilled gasoline or diesel fuel or vented LPG is both wasteful and hazardous.

__16. If a light load has to be moved a short distance, use a hand truck rather than a fork lift. Be sure fork lifts are used for material handling, not personal transportation.

__17. Be sure pneumatic fork lift tires are properly inflated. Underinflation both damages tires and wastes fuel.

__18. Avoid using a far larger fork lift then required. For instance, use a 2000 pound lift to maneuver oil barrels rather than a 6000 pound lift.

__19. Avoid excessive fork lift idling. Start a lift only when there is work to be done - and stop it as soon as it is completed.

__20. Avoid making a habit of using a drastically oversized crane for a drastically undersized load. If a machine frequently requires a crane to load small work pieces, consider installing a small jib crane with an electric hoist. This both frees up the main crane for heavier jobs and saves energy.

__21. Install automatic timers to shut down crane motor generators if no crane moves are made within ten minutes.

Paint Line Operations

__1. Consider use of airless spray instead of air spray paint application. While it requires about 9.5 HP to atomize 1 GPM using air spray, it only requires about 1.3 HP to atomize 1 GPM using airless spray. Airless spray is particularly suited to large, heavy work pieces that must be painted with one coat, in place, such as heavy construction equipment, barges, structural steel, or railroad cars.

__2. Since natural gas is a decreasing resource, investigate the applicability of ultra-violet cured metal finishes to your product. Frequently, product redesign may enable the use of ultra-violet post coating or may permit using pre-coated coil stock. In many cases, coil coating uses only about 20% of the energy required for post painting.

__3. Consider installation of direct fired paint ovens instead of indirect fired. The heat transfer coefficient for dirct fired is about 97% versus 60% for indirect fired, with comparable differences in fuel consumption.

__4. Investigate conversion to water base painting materials. Water base usually cuts energy consumption by reducing spray booth air flow, oven exhaust, air makeup requirements, and oven times. In some cases, finishing lines have reudced total natural gas consumption up to 45%.

__5. Research is currently being done to develop low temperature cure and air dry waterbase coatings. Current future forecasts often predict water base may account for up to 60% of the industrial finishing market by 1985.

__6. Consider utilizing gas fired washer combustion products to provide heat for dry off oven. This would be paricularly applicable to direct fired washers.

	APPLIES	DOES NOT APPLY	COMMENTS
__7. If your product configuration is applicable, consider converting to a high intensity infra-red curing which uses as little as 10% of the energy required for a comparable gas fired oven.			
__8. Investigate converting paint ovens to the "Raw Oven Exhaust Recycle Process". This system returns part of the oven exhaust back to the oven after passing through an incinerator.			
__9. Investigate conversion to airless paint drying from conventional oven baking. This system holds oven oxygen content to as low as 1%, with resulting reductions in oven exhaust and gas requirements.			
__10. Reduce spray booth/makeup air temperature to 65° - 68°.			
__11. Investigate installing electric ovens instead of gas or oil fired. Higher operating costs are somewhat reduced by better temperature control, constant one-fuel operation, and more readily controlable oven atmosphere.			
__12. Consider insulating the entire paint line parts washer to reduce heat loss. Some plant operators estimate they have achieved up to 20% fuel reduction in metal pretreatment operations after insulating parts washers.			
__13. If insulating the entire washer is not feasible, investigate insulating the heated portion of the washer.			
__14. Consider additional paint oven wall insulation. Doubling the present thickness (usually only 2") will cut wall losses in half. Since most paint oven heat is lost through oven roofs, this portion in particular should be well insulated.			
__15. Consider utilizing ambient temperature solvent flash off if possible. In many casses, a slightly longer or slower conveyor may be all that is required.			
__16. Considerable heat is lost through oven "air seals", which are generally ineffective. Consider installation of bottom entry/exit oven, which better retain heated air within the oven.			
__17. Consider installations of oil fired paint ovens instead of gas fired. New oven technology can minimize paint discoloration and soot problems if a light, low sulfur (1%), oil is used.			
__18. Consider heat recovery equipment, such as "heat pipes", in spray booth and bake oven stacks. If heat recovery equipment is used, a regular maintenance program is required to minimize heat losses caused by paint residue build up.			
__19. Consider switching to low or ambient temperature parts washer cleaners and phosphating compounds. For instance, iron phosphates are now being successfully used at 100-120°F. in some applications.			
__20. Investigate staging spray booth air flow. If painters work only in the first section, with automatic spray equipment in the remaining zones, the booth air can flow into the first zone, and be exhausted to the other zones. In many cases, solvent concentration in the final zone would still be below the 25% LFL limit.			

	APPLIES	DOES NOT APPLY	COMMENTS
__21. Replacing manual spray with automatic paint spraying machinery may permit a reduction in spray booth air velocity with a resultant make up air reduction. Material flammability and toxicity must be investigated to determine if any reductions are feasible. This normally requires approval from insurance inspectors, fire inspectors, O.S.H.A., and any other applicable agencies.			
__22. Investigate using process steam condensate as heat source for paint line parts washer tanks.			
__23. Use a fixed orifice rather than an adjustable valve to meter water into process or paint line constant overflow tanks for minimum flow.			
__24. Check booth velocity carefully to avoid over exhausting. Consider using electrostatic spray since this usually permits a reduction of booth velocity of about 40%.			
__25. Investigate interlocking paint line conveyors with parts washers and bake ovens.			
__26. Investigate the feasibility of operating fume incinerators at reduced temperatures.			
__27. If paint line or process exhausts include extremly high solvent concentrations, investigate recovering and re-refining these otherwise wasted solvents. In some cases, solvents have been reclaimed at an energy cost 1/5 - 1/6 the price of new solvent.			
__28. Be sure plant is not occasionally under negative pressure. Negative pressure can starve gas burners resulting in a fuel rich flame with excess CO. Negative pressure also results in increased air infusion through walls and windows, with resulting cold drafts and worker complaints.			
__29. Be sure all stages in a process are really necessary. In some applications, washer stages may be eliminated or partially shut down, as may dry off ovens.			
__30. If batch ovens are used, maximize loading and optimize working hours for highest energy efficiency. Similarly, minimize warm up time as much as possible.			
__31. Because solvents are increasingly scarce and expensive, consider filtering, distilling, or otherwise recycling solvent.			
__32. It may be possible to improve paint oven heat transfer by increasing circulating air velocities or volume and by utilizing heating system radiant energy. Improved heat transfer may permit increased travel speeds with resulting increases in production with little or no increase in fuel reuqirements.			
__33. Sequentially shut down ovens at end of shift or production run.			
__34. Attempt to schedule all paint line operations for one shift if feasible.			
__35. Be sure all gas immersion tubes used for liquid heating are clean (both interior and exterior) for best heat transfer.			
__36. Be sure all air filters are kept clean.			
__37. Change paint line conveyor speed and hook configuation as required with product changes to maximize productivity and minimize oven idle time.			
__38. Reduce conveyor speed when parts are not flowing through wash or bake ovens.			

VOLUME I

SECTION III

ENERGY ANALYSIS OF NINE SELECTED FOUNDRIES

INTRODUCTION

To substantiate energy reduction methods and procedures as addressed in Sections I and II, nine foundries were surveyed for the purpose of obtaining all necessary input data required to calculate potential energy reduction measures that would be applicable to all CCMA member companies.

The selected foundries used in this section are comprised of various foundry types and are fairly representative of the California Cast Metals Industry.

The selected foundries were very cooperative in providing much of the input data used in this Section. Lack of in-plant metering, especially in regards to gas flow rates to various equipment, and flue gas combustion analysis data precludes any guarantee as to the accuracy of the potential energy savings shown in each individual foundry energy analysis.

Gas utility companies in both northern and southern California are assisting in obtaining gas flow rates and combustion analyses information. Much of this information was not available at the time it was needed; therefore, in some instances input data is not factual and the anticipated energy savings shown are an approximation or order of magnitude only. Where such cases occur they will be noted as will the assumptions used in the computation of energy savings. It should be stressed that the percent savings shown for various processes is within the range of previously published data.

Electrical energy profile graphs are factual. The input data used was supplied by the appropriate electric utility company.

The electricity savings shown, for each individual foundry, are all cost related - no energy savings are possible by implementation of demand limiting and off-peak melting practises.

As stated in Section II part A, improved electric melt furnace design could be an area where effective energy savings could be realized. The unavailability of substantiated evidence as to the amount of energy savings and the associated cost of furnace improvements preclude documentation of such energy savings in the nine foundries surveyed.

Furnace manufacturers quote figures as high as 10% savings for improved furnace designs as previously listed in this study.

Every attempt has been made to simplify the methodology of procedures for calculating energy savings relative to melting, heat treating and ladle preheating operations.

Unfortunately, because of the many variables associated with foundry operations, it is impossible to reduce all mathematical formula's to graphic and tabulated form. It is therefore unavoidable that many mathematical functions must be accomplished to achieve the end results. The use of a simple calculator together with adequate audit data and reference to the mathematical models presented in Section II should make the task relatively simple.

TABLE 1

SUMMARY OF ENERGY USAGE AND EFFICIENCY RECORD 1979
SCHEDULE A-12 RATES

CODE	TONS SHIPPED	ENERGY CONSUMPTION 1/				ENERGY COST				UNIT OF PRODUCTION			ENERGY COST RELATIVE TO SALES	
		ELECTRIC	GAS	COKE	TOTAL ENERGY	ELECTRIC	GAS	COKE	TOTAL COST $	BTU X 10^6 TON	COST BTU X 10^6	COST/TON	GROSS SALES $	PERCENT
A	1,530	7,902	27,072	32,091	67,065	100,709	78,350	264,887	443,946	43.83	6.62	290.16	5,000,000	8.87
B	6,407	47,194	18,938	NONE	66,132	459,755	50,732	NONE	510,487	10.32	7.72	79.67	11,000,000	4.64
C	2,520	22,177	31,681	375	54,233	268,575	87,007	3,090	358,672	21.52	6.61	142.3	8,500,000	4.21
D	500	17,873	33,556	NONE	51,429	207,786	110,165	NONE	317,951	102.85	6.18	635.9	15,000,000	2.11
E	3,578	31,049	48,448	NONE	79,497	375,016	105,347	NONE	480,363	22.22	6.04	134.24	9,500,000	5.056
F	9,600	61,850	70,917	NONE	132,767	832,314	186,877	NONE	1,019,192	13.82	7.72	106.17	45,600,000	2.23
G	133	1,383	3,980	NONE	5,364	29,869	10,178	NONE	40,048	40.33	7.47	301.11	2,000,000	2.00
H	87	1,616	463	NONE	2,080	24,374	1,237	NONE	25,611	23.9	12.31	294.37	1,300,000	1.97
I	780	2,066	12,219	NONE	14,285	38,113	29,429	NONE	67,540	18.3	4.72	86.58	5,000,000	1.35

1/ ENERGY CONSUMPTION FIGURES ARE X 10^6 BTU.

2/ ABOVE FIGURES DO NOT INCLUDE ENERGY USE FOR TRANSPORTATION PURPOSES

SUMMARY OF ENERGY USAGE AND EFFICIENCY RECORD

1980 CALENDAR YEAR (PROJECTED)[3/]

CODE	TONS SHIPPED	ENERGY CONSUMPTION[1/]				ENERGY COST[4/] [5/]				UNIT OF PRODUCTION			ENERGY COST RELATIVE TO SALES	
		ELECTRIC	GAS	COKE	TOTAL ENERGY	ELECTRIC	GAS	COKE	TOTAL COST $	BTU X 10^6 TON	COST BTU X 10^6	COST/TON	GROSS SALES $	PERCENT
A	1,530	7,902	27,072	32,091	67,065	123,105	78,350	264,887	466,342	43.83	6.95	304.8	5,000,000	9.3
B	6,407	47,194	18,938	NONE	66,132	839,557	50,732	NONE	890,289	10.321	13.46	138.9	11,000,000	8.09
C	2,520	22,177	31,681	375	54,233	425,700	87,007	3,090	515,797	21.52	9.51	204.6	8,500,000	6.06
D	500	17,873	33,556	NONE	51,429	314,304	110,165	NONE	424,469	102.85	8.25	848.93	15,000,000	2.82
E	3,578	31,049	48,448	NONE	79,497	551,696	105,347	NONE	657,043	22.22	8.26	183.6	9,500,000	6.91
F	9,600	61,850	70,917	NONE	132,767	1,170,233	186,877	NONE	1,357,110	13.82	10.22	141.36	45,600,000	2.97
G	133	1,383	3,980	NONE	5,364	40,334	10,178	NONE	50,513	40.33	9.41	379.7	2,000,000	2.52
H	87	1,616	463	NONE	2,080	29,806	1,237	NONE	31,043	23.9	14.9	356.8	1,300,000	2.38
I	780	2,066	12,219	NONE	14,285	42,893	29,429	NONE	72,322	18.3	5.06	92.72	5,000,000	1.44

1/ Energy consumption figures are x 10^6 Btu.
2/ Above figures do not include energy use for transportation purposes.
3/ 1979 electrical consumption figures used to project anticipated energy cost.
4/ Electrical energy costs based on 1980 "time of day" billing rates.
5/ All other energy costs (gas and coke) are based on 1979 unit rates.

TABLE 2

TABLE 3

SUMMARY OF ENERGY USAGE AND EFFICIENCY RECORD (POTENTIAL SAVINGS)

ALTERNATE 1

CODE	TONS SHIPPED	ENERGY CONSUMPTION[1/]				ENERGY COST $				UNIT OF PRODUCTION			ENERGY COST RELATIVE TO SALES	
		ELECTRIC	GAS	COKE	TOTAL ENERGY	ELECTRIC	GAS	COKE	TOTAL COST $	BTU X 10^6 TON	COST BTU X 10^6	COST/TON	GROSS SALES $	PERCENT
A	1,530	7,902	14,624	25,166	47,692	119,610	42,373	207,727	369,710	31.17	7.75	241.6	5,000,000	7.39
B	6,407	47,194	10,345	NONE	57,539	830,397	27,792	NONE	858,189	8.98	14.9	133.9	11,000,000	7.80
C	2,520	22,177	15,551	375	38,104	421,383	47,447	3,090	471,920	15.12	12.38	187.26	8,500,000	5.52
D	500	17,782	20,632	NONE	38,414	38,242	67,515	NONE	375,757	76.83	9.78	751.5	15,000,000	2.50
E	3,578	31,049	25,657	NONE	56,661	533,034	55,209	NONE	588,243	15.83	10.38	164.4	9,500,000	6.19
F	9,600	61,850	49,348	NONE	111,198	1,155,216	132,700	NONE	1,287,916	11.58	11.58	134.15	45,600,000	2.82
G	133	1,383	2,052	NONE	3,435	39,217	6,242	NONE	45,459	25.82	13.23	341.79	2,000,000	2.27
H	87	1,616	463	NONE	2,080	27,745	1,237	NONE	28,982	23.9	13.93	331.6	1,300,000	2.22
I	780	2,066	9,584	NONE	11,650	40,111	22,183	NONE	62,294	4.9	5.34	79.86	5,000,000	1.24

1/ ENERGY CONSUMPTION FIGURES ARE X 10^6 BTU.

2/ ABOVE FIGURES DO NOT INCLUDE ENERGY USE FOR TRANSPORTATION PURPOSES.

SUMMARY OF ENERGY USAGE AND EFFICIENCY RECORD (POTENTIAL SAVINGS)

ALTERNATE 2

CODE	TONS SHIPPED	ENERGY CONSUMPTION 1/ ELECTRIC	GAS	COKE	TOTAL ENERGY	ENERGY COST ELECTRIC	GAS	COKE	TOTAL COST $	UNIT OF PRODUCTION BTU X 10^6 TON	COST BTU X 10^6	COST/TON	ENERGY COST RELATIVE TO SALES GROSS SALES $	PERCENT
A	1,530	SAME AS ALTERNATE - 1											5,000,000	7.39%
B	6,407	47,194	10,345	NONE	57,539	771,987	27,792	NONE	799,779	8.98	13.89	124.82	11,000,000	7.27%
C	2,520	22,177	15,551	375	38,104	364,636	47,447	3,090	415,173	15.12	10.89	164.75	8,500,000	4.88%
D	500	17,782	20,632	NONE	38,414	304,187	67,515	NONE	371,702	76.83	9.67	743.4	15,000,000	2.47%
E	3,578	SAME AS ALTERNATE -1											9,500,000	6.19%
F	9,600	61,850	49,348	NONE	111,198	1,067,615	132,700	NONE	1,200,315	11.58	10.79	125.03	45,600,000	2.63%
G	133	SAME AS ALTERNATE - 1											2,000,000	2.27%
H	87	SAME AS ALTERNATE - 1											1,300,000	2.22%
I	780	SAME AS ALTERNATE - 1											5,000,000	1.24%

1/ ENERGY CONSUMPTION FIGURES ARE X 10^6 BTU.

2/ ABOVE FIGURES DO NOT INCLUDE ENERGY USE FOR TRANSPORTATION PURPOSES.

TABLE 4

ENERGY AND COSTS COMPARISONS

	PRESENT CONDITION[2]		ALTERNATE #1		ALTERNATE #2		ALTERNATE #3		PERCENT SAVINGS[1]	
FOUNDRY	ENERGY	COST	ENERGY	COST	ENERGY	COST	ENERGY	COST	ENERGY	COST
A	67,065	466,342	47,692	369,710	--	--	--	--	29%	21%
B	66,132	890,289	57,539	858,189	57,539	799,779	--	--	13%	11%
C	54,233	515,797	38,104	471,920	38,104	415,173	38,103	434,603	30%	20%
D	51,429	424,469	38,414	375,757	38,414	371,702	38,414	366,479	26%	14%
E	79,497	657,043	56,661	588,243	--	--	--	--	29%	11%
F	132,767	1,357,110	111,198	1,287,916	111,198	1,200,315	--	--	16%	12%
G	5,364	50,513	3,435	45,459	--	--	--	--	36%	10%
H	2,080	31,043	2,080	28,982	--	--	--	--	-0-	7%
I	14,285	72,322	11,650	62,294	--	--	--	--	19%	14%
AVERAGE SAVINGS (NINE FOUNDRIES)									22%	13.3%

[1]Energy and cost saving percentages based on the most favorable alternate.

[2]Present energy costs have been escalated to reflect 1980 electrical energy cost increase, all other energy cost (i.e. gas and coke) are based on 1979 rates.

NOTE: The reason for escalating the electrical energy cost is to show the enormous impact of the "Time of Day" billing rate increase in 1980.

Also, percent savings for implementation of furnace controls and off-peak melting would have been unrealistic when compared against the actual 1979 electrical costs incurred by each foundry.

TABLE 5

SECTION III

TABLE OF CONTENTS

FOUNDRY "A"

PART A

GENERAL DESCRIPTION

The foundry produces jobbing type Ductile iron and Meehanite casting, averaging 17 pounds each. Cope and drag green sand molding systems and a no-bake line operates one shift per day.

Facilities

Building Area	-	90,000 Square Feet
Manning Total	-	139
Average Shipments	-	1,530 Tons/Year
Average Sales Volume	-	$5.0 Million
Average Foundry Yield	-	39.3%

Melting Furnaces

Capacities: 2 Cupolas, 42" diameter water cooled with apprx. 1% O_2 enrichment melt at 4.5 tons/hr
1 Coreless Induction furnace, 340 KW
3,000 pound capacity (600# charge)

Melting: 8 hours per day - 5 days per week
48 weeks per year

Equipment

Molding comprises 4 squeezer machines, 3 cope and drag units and a no-bake mixer, 350 per minute capacity. Sand plant mixing capacity is 3,000 pound batch muller with 100 ton storage and distribution system. Core sand preparation is in 75 pound capacity batch mixers serving 5 Isocure machines. Two shell core machines are available. The cleaning department provides for cut-off by abrasive and gas torch methods. Heat treat furnaces operate on 21-hour and 18-hour cycles. Air compressors in three sizes operate up to 20 hours per day. No propane or fuel oil is used in the process except for trucks.

NOTE: Above melting and heat treat operating characteristics are based on calendar year 1979.

PART B

ENERGY USE TABLES

FOUNDRY "A"

ELECTRICAL POWER USAGE*

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY	74,560	N/A	N/A	N/A	N/A	N/A	N/A	3,833.00
FEBRUARY	78,720							3,835.00
MARCH	19,520							1,136.00
APRIL	62,080							3,025.00
MAY	58,880							2,892.00
JUNE	38,400							1,891.00
JULY	22,720							1,202.00
AUGUST	35,840							1,765.00
SEPTEMBER	23,680							1,219.00
OCTOBER	26,560							1,365.00
NOVEMBER	22,080							1,246.00
DECEMBER	49,920							2,590.00
TOTALS	512,960							25,999.00

* GENERAL PLANT ELECTRIC POWER USAGE.

AVERAGE POWER COSTS $= \frac{25,999}{512,960} =$ $0.051/KWH

TABLE 1

FOUNDRY "A"

ELECTRICAL POWER USAGE*

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY	179,400	N/A	N/A	N/A	N/A	N/A	N/A	7,531.00
FEBRUARY	178,200							7,045.00
MARCH	90,600							4,135.00
APRIL	133,200							5,509.00
MAY	176,100							6,889.00
JUNE	173,700							6,893.00
JULY	119,100							5,125.00
AUGUST	167,400							6,658.00
SEPTEMBER	150,900							6,133.00
OCTOBER	153,300							6,432.00
NOVEMBER	148,200							6,446.00
DECEMBER	132,900							5,914.00
TOTALS	1,803,000							74,710.00

* MELT FURNACE ELECTRICAL POWER USAGE.

AVERAGE POWER COST $= \frac{74,710}{1,803,000} = \$ 0.041/\text{KWH}$

COST SUMMARY (PLANT & MELT FURNACE)

SERVICE	KWH	COST
FURNACE	1,803,000	74,710.00
GENERAL PLANT	512,960	25,999.00
TOTALS	2,315,960	100,709.00

TABLE 1

FOUNDRY "A"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
JANUARY	32,288	3,228.8	$ 8,609.00
FEBRUARY	31,672	3,167.2	8,445.00
MARCH	12,389	1,238.9	3,304.00
APRIL	27,027	2,702.7	7,206.00
MAY	24,784	2,478.4	6,608.00
JUNE	25,081	2,508.1	7,175.00
JULY	17,232	1,723.2	5,106.00
AUGUST	22,930	2,293.0	6,793.00
SEPTEMBER	16,508	1,650.8	4,891.00
OCTOBER	21,890	2,189.0	6,805.00
NOVEMBER	18,617	1,861.7	6,359.00
DECEMBER	20,306	2,030.6	7,049.00
TOTALS	270,724	27,072.4	$ 78,350.00

HEAT CONTENT OF GAS = 1,000 BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{78,350}{270,724}$ = $ 0.289 PER THERM

TABLE 2

FOUNDRY "A"

ANNUAL COKE CONSUMPTION

PERIOD	TONS	BTU X 10^6 (@ 12,500 BTU/LB)	COST
JULY	13	325	$ 2,264.00
AUGUST	61.1	1,527.5	10,801.00
SEPTEMBER	64.4	1,610	10,888.00
OCTOBER	134.1	3,352.5	23,772.00
NOVEMBER	95	2,375	17,001.00
DECEMBER	177.8	4,445	30,656.00
JANUARY	169.4	4,235	31,367.00
FEBRUARY	105.4	2,635	19,429.00
MARCH	56.1	1,402.5	10,801.00
APRIL	141	3,525	56,551.00
MAY	143.6	3,590	27,595.00
JUNE	122.74	3,068.5	23,762.00
TOTALS	1,283.64	32,091	$ 264,887.00

$$\text{AVERAGE COST PER TON} = \frac{264,887}{1,283.64} = \underline{\$\ 206.35}$$

TABLE 3

FOUNDRY "A"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
MOLDING #1 DEPARTMENT							
CONVEYOR	DELIVERY				5		
CONVEYOR	GOODMAN				10		
SHAKEOUT					10		
CASTING CONVEYOR					7.5		
INCLINED CONVEYOR					5		
INCLINED CONVEYOR					5		
HOPPER CONVEYOR					5		
DUST COLLECTOR					25		
SPILLAGE CONVEYOR					5		
SAND MILL					15		
SAND MILL					50		
BUCKET CONVEYOR					7.5		
MISCELLANEOUS					18		
SUBTOTAL					168		
MOLDING #2							
CRANES					50		
PRE MIX					8.5		
SHAKEOUT					20		
MISCELLANEOUS					5		
SUBTOTAL					83.5		

TABLE 4

SHEET 1 of 3

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
CORE ROOM							
MYERS HOIST	ROBBINS				10		
MIXERS					11		
DELIVERY CONVEYOR					9		
SAND MIXER					5		
HOIST	SHEPHERD NILES				5		
MISCELLANEOUS					11		
•SUBTOTAL					51		
CLEANING DEPARTMENT							
GRINDERS					50		
TUMBLAST					25		
SWING GRINDER					50		
OVEN #1					10		
CUTOFF SAW					25		
DUST COLLECTOR					15		
CRANES					44		
CASTING BURNER					5		
CASTING FAN					10		
MISCELLANEOUS					15		
SUBTOTAL					249		

TABLE 4

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	SERVICE
PATTERN SHOP							
TABLE SAW #1					7.5		
BAND SAW					5		
BAND SAW					5		
MISCELLANEOUS					6		
SUBTOTAL					23.5		
MELTING DEPARTMENT							
CUPOLA BLOWER					30		
SMOG BLOWER					50		
INDUCTION FURNACE		3,000#			6	340	
MISCELLANEOUS					7		
SUBTOTAL					93		
GENERAL							
COMP. #1					125		
COMP. #2, 3 AND 4					220		
MISCELLANEOUS					11		
SUBTOTAL					356		
GRAND TOTAL					1,024	340	

TABLE 4

FOUNDRY "A"

DESCRIPTION AND FLOW RATES OF GAS-FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
HEAT TREAT FURNACE #1	CAR		PREMIX	21	21	N/A	6,300
HEAT TREAT FURNACE #2	CAR		PREMIX	18	12	N/A	3,840
LADLE HEATERS (5)	-	5	-	3.5	21	N/A	1,000*
TAP HOLE TORCH		1	ATMOS.	3	21	N/A	200*
CUPOLA BED IGNITER			TORCH	2	21	N/A	200*
TOTALS							

*ESTIMATED GAS USAGE.

TABLE 5

FOUNDRY "A"

1979 ENERGY - EFFICIENCY RECORD

MONTH OR YEAR RECORDED	1979-1980
UNITS OF PRODUCTION	1,530 NET GOOD TONS SHIPPED
FUEL COSTS	
• Electricity	$ 100,709.00
• Natural Gas	78,350.00
• Propane	---
• Oil	---
• Coke	264,887.00
• Other	---
TOTAL	$ 443,946.00

ENERGY USED

• KWH	2,315,960	x 3,412 Btu	=	7,902	Btu x 10^6
• Mcf Gas	27,072		1/	27,072	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=	None	
• Gal. Oil		x 140,000 Btu	=	None	
• Coke - lb.	2,567,280	x 12,500 Btu	=	32,091	Btu x 10^6
•			=		
		TOTAL BTU		67,065	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}\quad 67,065}{\text{(Units)}\quad 1,530\text{ tons}} = 43.83 \text{ Btu} \times 10^6/\text{ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}\quad 443,946}{\text{(Million Btu)}\quad 67,065} = 6.62 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}\quad 443.946}{\text{(Units)}\quad 1,530\text{ tons}} = \$\,290.16 \text{ Cost/ton}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 6

FOUNDRY "A"

ENERGY - EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED		1980 Projected (Electric only)	
UNITS OF PRODUCTION		1,530	
FUEL COSTS			
• Electricity	$	123,105 2/	
• Natural Gas		78,350.00	
• Propane		--	
• Oil		--	
• Coke		264,887.00	
• Other		--	
TOTAL	$	466,342	

ENERGY USED				
• KWH 2,315,960	x 3,412 Btu	=	7,902	Btu x 10^6
• Mcf Gas 27,072		1/	27,072	Btu x 10^6
• Gal. Propane	x 91,600 Btu	=	None	
• Gal. Oil	x 140,000 Btu	=	None	
• Coke - lb.	x 12,500 Btu	=	32,091 Btu x 10^6	
•		=		
TOTAL BTU			67,065	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{67,065}{1,530}$ = 43.83 Btu x 10^6/Tons

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{466,342}{67,065}$ = $ 6.95 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{466,342}{1,530 \text{ Tons}}$ = $ 304.79 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with the new billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of demand control.

3/ All other energy costs are 1979 rates.

TABLE 7

PART C

PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE A

CASTING METAL DI & GI

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	459.1	216.6	N/A	
FEBRUARY	285.6	142.3		
MARCH	152.0	44.4		
APRIL	382.1	147.8		
MAY	389.2	163.1		
JUNE	332.6	152.1		
JULY	N/A	99.5		
AUGUST		154.1		
SEPTEMBER		77.8		
OCTOBER		141.7		
NOVEMBER		82.7		
DECEMBER		80.9		
TOTALS	3,890	1,530		$5,000,000

AVERAGE MELT TONS/DAY = 30.0

REPORTED % SCRAP CASTINGS 14.17

REPORTED % MELT LOSS 10.8

AVERAGE FOUNDRY YIELD % 39.3

AVERAGE SALES VALUE/LB. $ 1.63

*Melting on alternate days only

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS

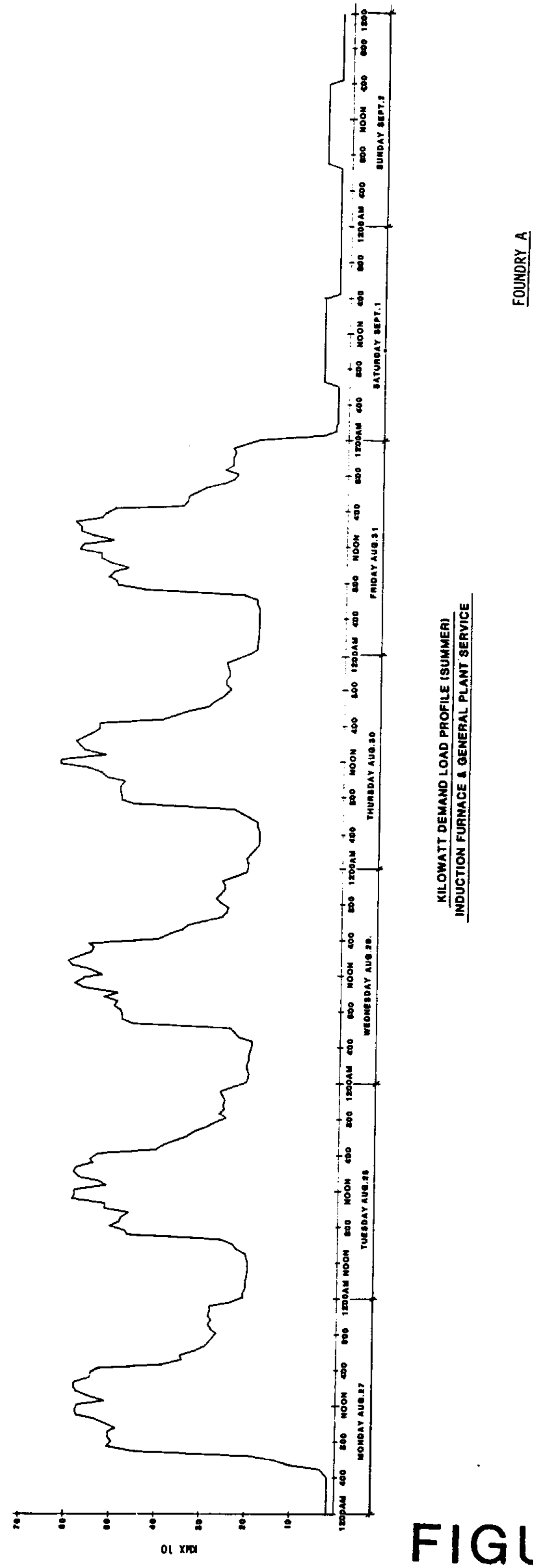

FOUNDRY A
KILOWATT DEMAND LOAD PROFILE (SUMMER)
INDUCTION FURNACE & GENERAL PLANT SERVICE
KW X 10
MONDAY AUG.27
TUESDAY AUG.28
WEDNESDAY AUG.29
THURSDAY AUG.30
FRIDAY AUG.31
SATURDAY SEPT.1
SUNDAY SEPT.2

FIGURE 1

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES

HEAT TREATING UNIT NO. 1

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	MODEL N/A
SIZE 106" x 111" x 18'-4"	TYPE PREMIX SIZE 6.3×10^6 BTU/HR
CAPACITY N/A LBS.	FUEL NATURAL GAS
TYPE OF LINING CONVENTIONAL	RECUPERATOR MAKE NONE
WALL THICKNESS N/A INCH	MODEL -- TEMP -- °F
BLOWER MAKE N/A	TYPE -- SIZE --
MODEL N/A	CONTROLS MAKE --
SIZE -- CFM. PRESS -- "WG	TYPE --
VOLT -- HP --	

TYPE OF HEAT TREAT CYCLE ALLOY

HEAT TREAT CYCLE - HEATUP 5.5 HRS	FUEL/AIR RATIO N/A
- SOAK 6.5 HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
-COOL DOWN 9 HRS	SHELL MEAN TEMPERATURE N/A °F
CYCLES PER WEEK 5	FURNACE PRESSURE N/A "WC
TEMPERATURE 1,650° - 1,350 °F	
AVERAGE LOAD N/A LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH -- AIR, __ H20 -- OIL	N/A % CO_2
QUENCH TEMPERATURE -- °F	FUEL CONSUMPTION 6,300 CFH THERMS/CYCLE 410

WALL AREA 878 SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE N/A °F

ENERGY COST/THERM $ 0.3

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

TABLE 1

TABLE 3 (CONTINUED)

HEAT TREATING UNIT NO. 2

FURNACE MAKE: N/A	BURNER MAKE: N/A
MODEL: N/A	MODEL: N/A
SIZE: 96" x 96" x 162"	TYPE: N/A SIZE: N/A BTU/HR
CAPACITY: N/A LBS.	FUEL:
TYPE OF LINING: N/A	RECUPERATOR MAKE: NONE
WALL THICKNESS: N/A INCH	MODEL: -- TEMP: -- °F
BLOWER MAKE: N/A	TYPE: -- SIZE: --
MODEL: N/A	CONTROLS MAKE: --
SIZE: -- CFM. PRESS: -- "WG	TYPE: --
VOLT: -- HP: --	
TYPE OF HEAT TREAT CYCLE:	ALLOY:
HEAT TREAT CYCLE - HEATUP 7.75 HRS	FUEL/AIR RATIO: N/A
- SOAK 6.75 HRS	FLUE TEMPERATURE: HIGH N/A °F LOW N/A °F
-COOL DOWN 18 HRS	SHELL MEAN TEMPERATURE: N/A °F
CYCLES PER WEEK: 4	FURNACE PRESSURE: N/A "WC
TEMPERATURE: 1,650 °F	
AVERAGE LOAD: N/A LBS	FLUE ANALYSIS (HIGH): N/A % CO
CASTING: N/A LBS	N/A % O_2
BASKETS: N/A LBS	N/A % CO_2
STOOLS: N/A LBS	LOW: N/A % CO
LOAD DENSITY: N/A LBS/WFT	N/A % O_2
QUENCH -- AIR, ___ H20 -- OIL	N/A % CO_2
QUENCH TEMPERATURE: -- °F	FUEL CONSUMPTION 3,840 CFH THERMS/CYCLE 387

WALL AREA ______ SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE N/A °F

ENERGY COST/THERM $ 0.3

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

TABLE 1

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	N/A
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	No	TYPE OF LINING	N/A
INSIDE TEMP	N/A °F	OUTER SHELL TEMP	N/A °F
AMBIENT TEMP	°F		
GAS USAGE/HR	200 CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	HRS	FLUE TEMP	N/A °F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	None	RECUPERATOR EFFCY	None
FUEL COST/THERM $	0.3	ANNUAL USE	840 BTU x 10^6
NUMBER OF UNITS IN USE	Average of 5[1/]		

1/ Used 3.5 hours per day - 240 days per year.

TABLE 2

OPERATIONAL DATA FACT SHEET

CUPOLA DATA (TWO UNITS)

CUPOLA DIA SHELL 42 INS REFRACTORY THICKNESS N/A

LINING None INS WATER COOLING GPM N/A

HEIGHT OF TUYERES ABOVE HEARTH N/A INS

LAUNDER LENGTH N/A WIDTH N/A

METAL TO COKE RATIO 5.3:1 BED COKE 5,600 LBS

MELT RATE 4.2 TPH COKE ADDITION/HR 1,590 LBS

BLAST RATE N/A CFM PRESSURE N/A ONZ

NUMBER OF ROWS OF TUYERES 6 SPACING N/A

COOLING WATER USAGE 204,000 GALLONS GPM $T_1 - T_2$ 60 °F

FAN HP 30 MISC. HP 50

HOT BLAST TEMP None °F RECUPERATOR CAP None BTU/HR

AFTER BURNER RATING BTU/HR None

OXYGEN ENRICHMENT PERCENT ADDITION One %

MELTING PERIOD; BLAST ON 5.78 1/ BLAST OFF Not Applicable

COKE BREEZE ADDITION, PERCENT OF COKE None %

ANTHRACITE ADDITION, PERCENT OF COKE None %

1/ Average figure.

TABLE 3

PART E

ENERGY CONSERVATION POTENTIAL

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15- to 30-minute periods.

ELECTRICAL ENERGY COST SAVINGS

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Based on a sample billing period of one year. The cost reduction potential is:

1. Demand Control

	Total
Normal melting demand cost 1/	\$11,885
Demand limited cost 1/	8,390
Savings	\$3,495/yr

$$\text{Percent savings} = \frac{\text{reduction in cost}}{\text{normal demand cost of melting}} = 29.4\%$$

For graphic illustration of methodology used in calculating electrical savings see Figure 1.

1/ See TABLE 1

DEMAND CONTROLLING

The following approximate cost savings can be realized by the installation of demand limiting controls. Controlling the Peak Kilowatt demand to 350 kilowatts.

Potential Cost Savings = $ 130 per month

Annual Cost Savings = $ 1,670

For graphic illustration of methodology used for calculating cost saving see Figure 1.

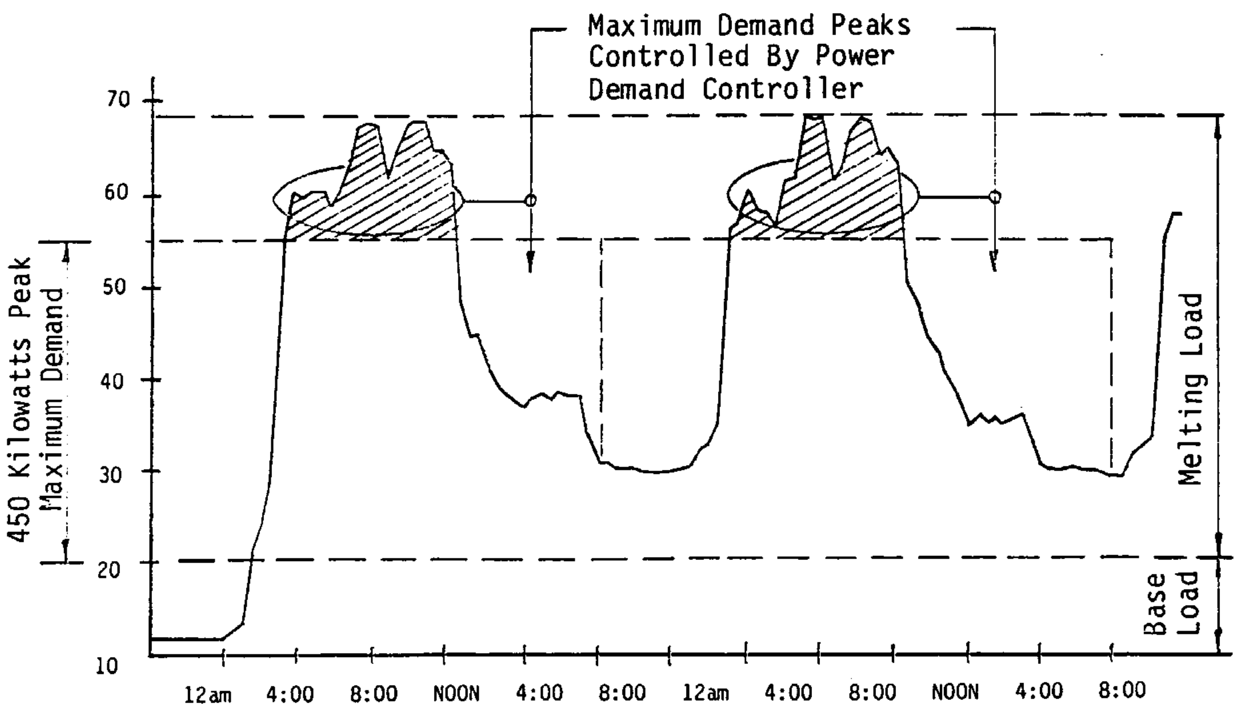


FIGURE 1. KILOWATT DEMAND LOAD PROFILE INDUSTRIAL BILLING RATE

FIGURE 1

DEMAND CONTROLLING

NORMAL MELTING COST			DEMAND CONTROLLING COST			
Month	Kilowatt Demand	Demand Charge	Kilowatt Demand	Demand Charge	Savings	%
Jan.	512	$994.24	350	$699.4	$294	29.6
Feb.	513	996.06			296	29.7
March	499	970.58			271	27.9
April	505	981.50			282	28.7
May	511	992.42			293	29.5
June	518	1,005.16			306	30.4
July	508	986.96			288	29.2
Aug.	503	977.86			278	28.5
Sept.	500	990.60			291	29.4
Oct.	514	997.88			298	29.9
Nov.	513	996.06			297	29.8
Dec	513	996.06			297	29.8
		$11,885		$8,390	3,495	

Potential yearly saving (average) = 29.4%
Based on a maximum demand of 350 kw.

TABLE 1

Upgrading Heat Treat Furnaces

Amount of total gas consumed	=	270,724 therms/yr
Total natural gas cost	=	$ 78,350.00
Average cost per therm	=	$ 0.289
Maximum gas usage per hour:		
Heat Threat Furnace #1	=	6,300 cu.ft.
Heat Threat Furnace #2	=	3,840 cu.ft.
Total	=	10,140 cu.ft.
Average heat-up time (Total)	=	13.25 hours
Average holding time (Total)	=	13.25 hours
Total cycles per year	=	150

Assume yearly gas consumption attributed to heat treat operations is 80% of total plant gas input or (270,724 x 0.8) 216,000 therms/yr.

Approximately 56% energy savings can be realized by:

- Installing ceramic fiber linings - 12-inch thick
- Upgrading burner system and controls
- Adding combustion air preheating

Energy saved = 216,000 therms x 0.56 = 120,960 therms/yr

Cost Savings = 120,960 therms x 0.289 = $ 34,957.00

Upgrading Ladle Heaters

Quantity of ladle heaters used at one time	=	5
Hours of operation per year	=	882 hrs/yr
Assumed average gas consumption	=	1,000 cu.ft./hr

Total gas used per year:

(1,000 cu.ft./hr x 882 hrs)	=	882,000 cu.ft./yr.
	OR	8,820 therms

Approximately 40% energy savings can be realized by:

- Upgrading lining
- Installing ladle covers
- Upgrading burner system

Energy saved	=	8,820 therms x 0.4	=	<u>3,528 therms</u>
Cost savings	=	3,528 therms x 0.289	=	<u>$ 1,020.00</u>

UPGRADING CUPOLA OPERATION

Amount of coke consumed	=	1,283.64 Tons
Total cost of coke	=	$264,887.00
Average cost per ton	=	$206.35
Cupola size (diameter	=	42"
Cupola melt rate Tons/Hour	=	4.2
Total tons melted/Year	=	3,500 Tons
Metal to coke ratio (charged)	=	5.3 :1
Special conditions - O_2%		1.0

Energy (coke) savings can be realized by:

- Hot blast conditioning 22.8%
- Divided blast supply 26.2%

49.0%

Energy savings (charged coke only) =

$$\frac{3{,}000 \text{ melt tons}}{(5.3{:}1) \text{ coke usage/ton}} \times 0.49 = 277 \text{ tons}$$

Cost savings = 277 tons x $206.35 - $57,160/year

CONVERT TO ELECTRIC MELTING

Replacement of cupola melting with electric furnace melting involves consideration of multiple variables which occur in foundry operation. An in depth analysis is necessary to carry out a complete analysis and is not covered in this report.

PART F

ECONOMIC ANALYSIS

PART F

ECONOMIC ANALYSIS

Payback period is calculated as follows:

$$\frac{\text{Total Capital Investment}}{\text{Gross Energy Cost Reductions/Year}} = \text{Years}$$

Payback years for individual projects are listed in PART G based on order of magnitude costs as follows:

• Demand Controller		$ 4,000
• Upgrading Heat Treat Furnaces		80,000
• Upgrade Ladle Heaters		12,000
• Upgrading Cupola		250,000
	TOTAL	$346,000

The following conditions could lower the anticipated payback period considerably:

- Present day equipment costs used. However, the energy cost savings is based on 1979 calendar year average energy cost, except for electrical energy which is escalated to show approximate 1980 costs.
- No credit taken for government tax credit for installation of energy-saving devices.
- Calculation of return on investment utilizing life-cycle testing methods, which take into account depreciation, cost of money, and escalation of energy cost over the lifetime of the equipment, could possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD
Power factor correction				
Demand controllers	NONE	$3,495	$ 4,000	1.14
Off-peak melting				
Load shifting				
Upgrading heat treat furnaces	12,096	34,957	80,000	2.3
Upgrading ladle heaters	352	1,020	12,000	11.8
Upgrading cupola furnaces	6,925	57,160	250,000	4.4
TOTAL	19,373	96,632	346,000	3.58

Total Btu reduction/ton of castings shipped

$$= \frac{19,373 \times 10^6}{1,530} = 12.66 \times 10^6 \text{ BTU}$$

FOUNDRY "A"

PROJECTED ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED		1979/80 Calendar Year
UNITS OF PRODUCTION		1,530
FUEL COSTS		Net good tons shipped
• Electricity	$	119,610 2/
• Natural Gas		43,373
• Propane		--
• Oil		--
• Coke		207,727
• Other		--
TOTAL	$	369,710

ENERGY USED

• KWH	23,159.60	x 3,412 Btu	=	7,902	Btu x 10^6
• Mcf Gas	14,624	x	1/	14,624	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=	--	
• Gal. Oil		x 140,000 Btu	=	--	
• Coke - lb.	2,013,280	x 12,500 Btu	=	25,166 Btu x 10^6	
•			=		
TOTAL BTU				47,692	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{47{,}692}{1{,}530 \text{ Tons}} = 31.17 \text{ Btu} \times 10^6$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{369{,}710}{47{,}682} = \$\ 7.75 \quad \text{Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{369{,}710}{1{,}530 \text{ Tons}} = \$\ 241.6 \quad \text{Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ Electrical cost based on 1980 billing rates

ALTERNATE 1

SECTION III

TABLE OF CONTENTS

FOUNDRY "B"

PART A

General Description

Gray and ductile iron castings, average weight 8 pounds.

Green sand production operating two shifts per day, 5 days per week.

Facilities

Building Area	80,000 square feet
Manning Total	205 (two shifts)
Average Shipments	6,405 net tons/year
Annual Sales	$11.0 Million
Average Foundry Yield	60%

MELT FURNACES

Capacities - 2 Channel Induction 1,050 kW

20 tons capacity each - 2 tons/hour

Note - 1 inductor change at 6 week intervals (power off 3 - 4 days)

EQUIPMENT

2 Jolt-Squeeze 24" x 24" Molding machines

6 Squeeze molding machines

1 Automatic MP molding machine

Sand system with 44 tph capacity mullers. Core make equipment for shell, no-bake, gas cure and oil sand methods. Castings clean ing department operates 3 shifts per day and heat treatment equipment operates 3 shifts, 7 days per week.

PART B

ENERGY USE TABLES

FOUNDRY "B"

ELECTRICAL POWER USAGE**

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	1,039,200	2,346	96%	10,469	19,273	5,571	35,313	$ 35,313.00
FEBRUARY 1979	1,164,600	2,313	96	11,476	19,468	5,441	36,385	36,385.00
MARCH 1979	1,085,400	2,364	97	10,893	17,517	5,549	33,959	33,959.00
APRIL 1979	1,024,200	2,379	98	10,413	16,530	5,581	32,524	32,524.00
MAY 1979	1,088,400	2,379	98	10,914	16,909	5,581	33,404	33,404.00
JUNE 1979	975,000	2,361	98	10,011	16,189	5,543	31,743	31,743.00
JULY 1979	1,001,400	2,346	98	10,202	16,633	5,511	32,346	32,346.00
AUGUST 1979	679,200	2,346	98	7,637	11,281	5,511	24,429	24,429.00
SEPTEMBER 1979	1,032,000	2,346	97	10,453	17,141	5,505	33,099	33,099.00
OCTOBER 1979	993,600	2,352	97	27,431 1/	N/A	5,524	32,955	32,955.00
NOVEMBER 1979	975,600	2,373	96	10,059	18,516	5,568	34,143	34,143.00
DECEMBER 1979	948,000	2,313	96	32,190	N/A	N/A	32,190	32,190.00
TOTALS	12,006,600			162,148	169,457	60,885	392,490	$392,490.00

* INCLUDES STATE TAX.

** 440 VOLT SERVICE - A13 RATE.

1/ INCLUDES FUEL SERVICE CHARGE.

POWER COST $= \frac{392,490}{12,006,600} = \underline{\$0.032/KWH}$

TABLE 1

FOUNDRY "B"

ELECTRICAL POWER USAGE**

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	104,640	221		1,510	2,010	530	4,050	$ 4,050.00
FEBRUARY 1979	124,320	276		1,781	2,077	583	4,441	4,441.00
MARCH 1979	127,200	274		1,816	2,054	579	4,449	4,449.00
APRIL 1979	113,280	271		1,635	1,828	573	4,036	4,036.00
MAY 1979	108,960	266		3,357 1/	N/A	563	3,920	3,920.00
JUNE 1979	110,880	269		3,444 1/	N/A	569	4,013	4,013.00
JULY 1979	105,600	259		1,523	1,754	548	3,825	3,825.00
AUGUST 1979	87,360	259		1,293	1,451	548	3,292	3,292.00
SEPTEMBER 1979	111,840	250		1,602	1,857	530	3,989	3,989.00
OCTOBER 1979	104,160	250		3,364 1/	N/A	530	3,894	3,894.00
NOVEMBER 1979	99,360	250		1,442	1,885	530	3,857	3,857.00
DECEMBER 1979	102,720	262		1,493	1,949	554	3,996	3,996.00
TOTALS	1,300,320			24,260	16,865	6,637	47,762	$47,762.00

* INCLUDES STATE TAX.

** 220 VOLT SERVICE - A12 RATE.

1/ INCLUDES FUEL SERVICE CHARGE.

POWER COST $= \frac{47,762}{1,300,320} =$ $0.036/KWH

TABLE 1

FOUNDRY "B"

ELECTRICAL POWER USAGE**

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	50,880	N/A	N/A	N/A	N/A	N/A		$ 1,945.00
FEBRUARY 1979	49,120	N/A	N/A	N/A	N/A	N/A		1,771.00
MARCH 1979	48,480	N/A	N/A	N/A	N/A	N/A		1,713.00
APRIL 1979	43,200	N/A	N/A	N/A	N/A	N/A		1,565.00
MAY 1979	46,880	N/A	N/A	N/A	N/A	N/A		1,676.00
JUNE 1979	45,440	N/A	N/A	N/A	N/A	N/A		1,649.00
JULY 1979	46,080	N/A	N/A	N/A	N/A	N/A		1,670.00
AUGUST 1979	27,840	N/A	N/A	N/A	N/A	N/A		1,122.00
SEPTEMBER 1979	49,920	N/A	N/A	N/A	N/A	N/A		1,789.00
OCTOBER 1979	43,680	106	N/A	N/A	N/A	N/A		1,646.00
NOVEMBER 1979	38,560	108	N/A	N/A	N/A	N/A		1,537.00
DECEMBER 1979	34,880	108	N/A	N/A	N/A	N/A		1,420.00
TOTALS	524,960	-	-	-	-	-	-	$ 19,503.00

* 440 VOLT SERVICE - A12 RATE (CORE DEPARTMENT) <u>98.5 CONN HP</u>

COST SUMMARY (ALL SERVICES)

SERVICE	KWH	COST
440 VOLT - A13 RATE	12,006,600	$ 392,490
440 VOLT - A12 RATE	524,960	19,503
220 VOLT - A12 RATE	1,300,320	47,762
TOTALS	13,831,880	459,755

AVERAGE POWER COST $= \frac{459,755}{13,831,880} =$ <u>$0.033/KWH</u>

TABLE 1

FOUNDRY "B"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
JANUARY 1979	20,814	2,081.4	$ 5,260.00
FEBRUARY 1979	20,337	2,033.7	5,140.00
MARCH 1979	19,766	1,976.6	4,995.00
APRIL 1979	16,577	1,657.7	4,190.00
MAY 1979	16,525	1,652.5	3,166.00
JUNE 1979	9,007	900.7	2,355.00
JULY 1979	11,407	1,140.7	3,203.00
AUGUST 1979	9,296	929.6	2,649.00
SEPTEMBER 1979	17,856	1,785.6	5,014.00
OCTOBER 1979	16,166	1,616.6	4,540.00
NOVEMBER 1979	15,571	1,557.1	5,021.00
DECEMBER 1979	16,060	1,606.0	5,199.00
TOTALS	189,382	18,938.2	$ 50,732.00

HEAT CONTENT OF GAS = BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{50,732}{189,382}$ = $ 0.267 PER THERM

ANTICIPATED 1980 RATE INCREASE = 27%

TABLE 2

FOUNDRY "B"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
FURNACE #1	INDUCTION	20 tons	SEE LOAD PROFILE		-	1,100	440V - A13
FURNACE #2	INDUCTION	20 tons	SEE LOAD PROFILE		-	1,100	440V - A13
AIR COMPRESSOR #1	SULLAIR	-	N/A	N/A	75		440V - A13
AIR COMPRESSOR #2	SULLAIR	-	N/A	N/A	75		440V - A13
SAND MULLER #1	-		N/A	N/A	60		440V - A13
SAND MULLER #2	-		N/A	N/A	50		440V - A13
SUBTOTAL					260	2,200	
CORE DEPARTMENT							
AIR COMPRESSOR #3			N/A	N/A	75		440V - A12
WATER PUMP			N/A	N/A	2		
EXHAUST BLOWER			N/A	N/A	5		
HEATERS (3)	CONVER		N/A	N/A	75		
WELDER #1			N/A	N/A	25		
AIR COMPRESSOR #4	SULLAIR		N/A	N/A	75		
WELDER #2	G.E.		N/A	N/A	25		
MISCELLANEOUS			N/A	N/A	52		
SUBTOTAL					334		
FOUNDRY BUILDING							
SHAKER CONVEYER (3)			N/A	N/A	30		
SHAKEOUT			N/A	N/A	10		

TABLE 3

FOUNDRY "B"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
AERATORS (2)			N/A	N/A	20		
HUMTER PUMP					10		
COMPRESSOR (2)					80		
DUST CONTROL UNITS					70		
SHOT WHEEL					30		
BAGHOUSE					15		
CUTOFF WHEEL					15		
WELDERS (3)					60		
MISCELLANEOUS					91		
SUBTOTAL					431		
SUMMARY							
FURNACES					260	2,200	
CORE DEPARTMENT					334		
MAIN BUILDING					431		
TOTAL					1,025	2,200	

TABLE 3

Sheet 2 of 2

FOUNDRY "B"

DESCRIPTION AND FLOW RATES OF GAS FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
HEAT TREAT FURNACE #1	-		(TO BE RETIRED)			N/A	N/A
HEAT TREAT FURNACE #2	NEW			24	26	N/A	N/A
LADLE HEATING 4		4		3	21		250*
TOTALS						N/A	N/A

*Estimated

TABLE 4

FOUNDRY "B"

1979 ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED				1979	
UNITS OF PRODUCTION				6,407 TONS NET GOOD CASTINGS	
FUEL COSTS					
• Electricity			$	459,755.00	
• Natural Gas				50,732.00	
• Propane				NONE	
• Oil				NONE	
• Coke				NONE	
• Other.				NONE	
		TOTAL	$	510,487.00	
ENERGY USED					
• KWH	13,831,880	x 3,412 Btu	=	47,194	Btu x 10^6
• Mcf Gas	18,938	x 1,000,000	1/	18,938	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=	--	
• Gal. Oil		x 140,000 Btu	=	--	
• Coke - lb.		x 12,500 Btu	=	--	
•			=		
		TOTAL BTU		66,132	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{66{,}132}{6{,}407 \text{ (tons)}} = 10.321 \text{ Btu} \times 10^6\text{/ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{510{,}487.00}{66{,}132.00} = \$\ 7.72 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{510{,}487}{6{,}407 \text{ tons}} = \$\ 79.67 \text{ Cost/ton}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "B"

ENERGY-EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED			1980 PROJECTED (ELECTRICITY ONLY)	
UNITS OF PRODUCTION			6,407 TONS NET GOOD CASTINGS	
FUEL COSTS				
• Electricity		$	839,557.00	
• Natural Gas			50,732.00	
• Propane			NONE	
• Oil			NONE	
• Coke			NONE	
• Other			NONE	
	TOTAL	$	890,289.00	

ENERGY USED					
• KWH	13,831,880	x 3,412 Btu	=	47,194	$Btu \times 10^6$
• Mcf Gas		x	1/	18,938	$Btu \times 10^6$
• Gal. Propane		x 91,600 Btu	=	--	
• Gal. Oil		x 140,000 Btu	=	--	
• Coke - lb.		x 12,500 Btu	=	--	
•			=		
		TOTAL BTU		66,132	$Btu \times 10^6$

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}\quad 66{,}132}{\text{(Units)}\quad 6{,}407\text{ TONS}} = 10{,}321 \quad Btu \times 10^6$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}\quad 890{,}289}{\text{(Million Btu)}\quad 66{,}132} = \$\ 13.46 \quad Cost/Btu \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}\quad 890{,}289}{\text{(Units)}\quad 6{,}407} = \$\ 138.90 \quad \text{Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with "Time of Day" billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of "Off-Peak" melting and demand control.

3/ All other energy costs are 1979 rates.

TABLE 6

PART C

PRODUCTION STATISTICS

PART "C" PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE B

CASTING METAL G & D.I.

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY		554		
FEBRUARY		622		
MARCH		580		
APRIL		547		
MAY		580		
JUNE		520		
JULY		535		
AUGUST		363		
SEPTEMBER		550		
OCTOBER		530		
NOVEMBER		520		
DECEMBER		506		
TOTALS	10,700	6,407		$11,000,000

AVERAGE MELT TONS/DAY = ______

REPORTED % SCRAP ______

REPORTED % MELT LOSS ______

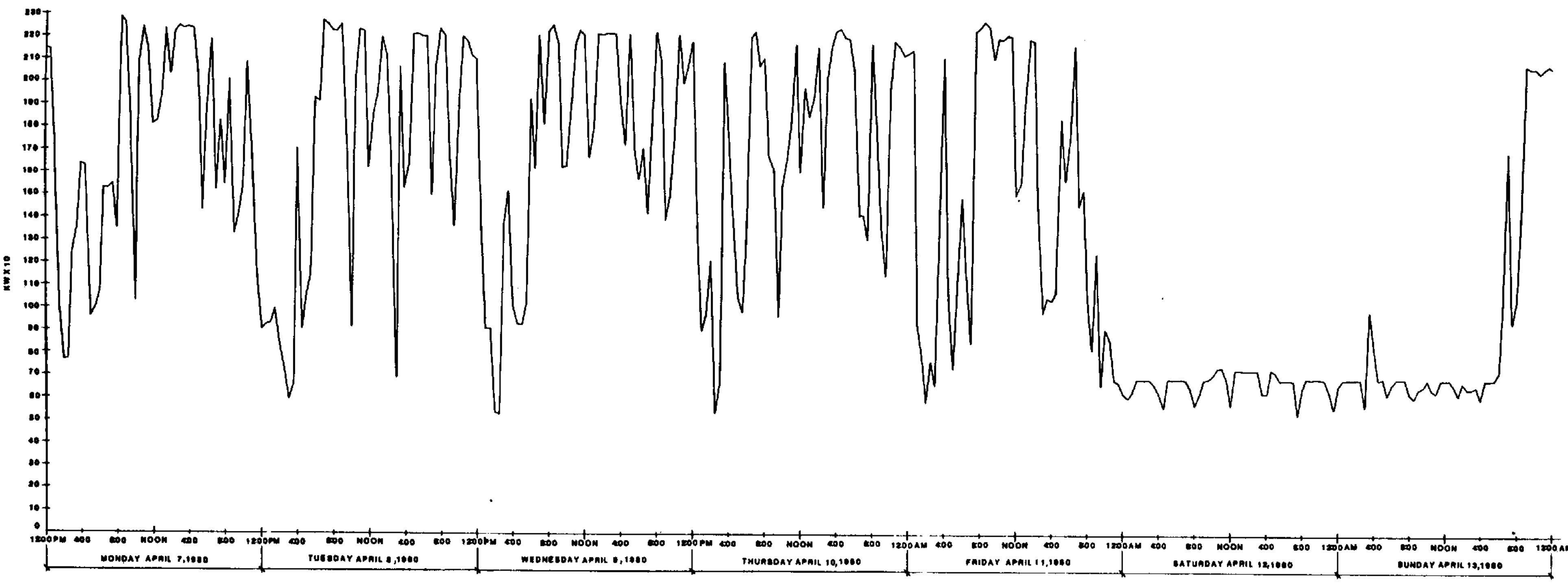
AVERAGE FOUNDRY YIELD % 60.0

SALES VALUE/LB. ______

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE (WINTER)
INDUCTION FURNACES & GENERAL PLANT SERVICE

FOUNDRY B

FIGURE 1

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACE

NOTE: This heat treat furnace has since been replaced by new furnace.

HEAT TREATING UNIT NO. (Old Furnace)

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	MODEL
SIZE N/A WFT.	TYPE Premix SIZE N/A BTU/HR
CAPACITY 16,000 LBS.	FUEL Natural Gas
TYPE OF LINING N/A	RECUPERATOR MAKE None
WALL THICKNESS N/A INCH	MODEL TEMP °F
BLOWER MAKE N/A	TYPE SIZE
MODEL N/A	CONTROLS MAKE
SIZE CFM. PRESS "WG	TYPE
VOLT HP	

TYPE OF HEAT TREAT CYCLE 16.5 Hr. Cycle ALLOY Ductile

HEAT TREAT CYCLE - HEATUP HRS	FUEL/AIR RATIO N/A
- SOAK HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
-COOL DOWN HRS	SHELL MEAN TEMPERATURE °F
CYCLES PER WEEK 10	FURNACE PRESSURE N/A "WC
TEMPERATURE 1,700 °F	
AVERAGE LOAD N/A LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH AIR, H2O OIL	N/A % CO_2
QUENCH TEMPERATURE °F	FUEL CONSUMPTION THERMS/CYCLE

WALL AREA N/A SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE N/A °F

EXTERNAL SURFACE AREA N/A SQ.FT.

ENERGY COST/THERM $ 0.274

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

TABLE 1

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACE

HEAT TREATING UNIT NO. (New Installation 1980)

FURNACE MAKE N/A

MODEL Car Bottom

SIZE 12'W. x 11'H. x 22'L. WFT.

CAPACITY 24,000 LBS.

TYPE OF LINING Pyro Brick

WALL THICKNESS 6" INCH

BLOWER MAKE N/A

MODEL N/A

SIZE ____ CFM. PRESS ____ "WG

VOLT ____ HP ____

BURNER MAKE N/A

MODEL N/A

TYPE Nozzle SIZE N/A BTU/HR

FUEL Natural Gas

RECUPERATOR MAKE None

MODEL ____ TEMP ____ °F

TYPE ____ SIZE ____

CONTROLS MAKE ____

TYPE ____

TYPE OF HEAT TREAT CYCLE 1 Cycle per Day ALLOY Ductile

HEAT TREAT CYCLE - HEATUP 2 HRS

- SOAK 6 HRS

-COOL DOWN 9 HRS

CYCLES PER WEEK 5

TEMPERATURE 1,700 °F

AVERAGE LOAD N/A LBS

CASTING N/A LBS

BASKETS N/A LBS

STOOLS N/A LBS

LOAD DENSITY N/A LBS/WFT

QUENCH ____ AIR, ____ H20 ____ OIL

QUENCH TEMPERATURE ____ °F

FUEL/AIR RATIO N/A

FLUE TEMPERATURE HIGH N/A °F LOW ____ °F

SHELL MEAN TEMPERATURE N/A °F

FURNACE PRESSURE N/A "WC

FLUE ANALYSIS (HIGH) N/A % CO

N/A % O_2

N/A % CO_2

LOW N/A % CO

N/A % O_2

N/A % CO_2

FUEL CONSUMPTION THERMS/CYCLE 350

WALL AREA N/A SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE N/A °F

EXTERNAL SURFACE AREA N/A SQ.FT.

ENERGY COST/THERM $ 0.274

HEAT TREAT LOADS/DAY One

HEAT TREAT LOADS/YEAR 240

TABLE 1

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

LADLE CAP TONS ____N/A____ HEAT CYCLES/DAY ____3____

LADLE AREA INSIDE ____N/A____ SQ FT. LINING THICKNESS ____N/A____

COVERED ____No____ TYPE OF LINING ____N/A____

INSIDE TEMP ____N/A____ ^{o}F OUTER SHELL TEMP ____N/A____ ^{o}F

AMBIENT TEMP ____Approximately 90^{o}F to 70^{o}F____ ^{o}F

GAS USAGE/HR ____250____ CU FT. CO_2 READING ____N/A____

COMBUSTION AIR ____N/A____ CFM PRESSURE ____N/A____ WG

PREHEAT CYCLE TIME ____N/A____ HRS FLUE TEMP ____N/A____ ^{o}F

REFRACTORY K VALUE ____N/A____ RS VALUE ____N/A____

BLOWER HP ____None____ RECUPERATOR EFFCY ____None____

FUEL COST/THERM $____0.274____ ANNUAL USE ____720____ BTU x 10^6

NUMBER OF UNITS IN USE ____Four____

NOTE: Burners are homemade with fixed air/fuel ratio fed from a 3/4" gas line.

TABLE 2

OPERATIONAL DATA FACT SHEET

CHANNEL INDUCTION FURNACE
(2 Units)

Furnace make	N/A	Transformer KVA	1,050
Model	-	Primary Voltage	N/A
Capacity	20 tons	Secondary Voltage	N/A

Output 10,700 tons/yr.

2 tons/Hour

Alloy Grey Iron

Melt cycle N/A minutes

Tap Quantity N/A minutes

Change Quantity N/A Lbs.

Tap temperature N/A ^{o}F

Holding Temperature N/A ^{o}F

Slag cycle N/A minutes

Fume collection N/A CFM

Water cooling N/A GPM, Temp....N/A...in ^{o}F.....N/A....Out ^{o}F

Type of Refractory N/A

Energy consumption N/A KWH/YR

Energy Cost 3.7 ¢/KW

TABLE 3

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this Study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this Study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15 to 30 minute periods.

UPGRADING HEAT TREAT FURNACE

Annual Gas Consumption (Total)	=	185,382 Therms/Yr.
Annual Gas Cost (Total)	=	$50,732
Average Gas Cost per Therm	=	$0.267
Annual Energy Used for Heat Treating - Assume (185,382 x .8)	=	148,306 Therms/Yr.

The above gas consumption figures are based on calendar year 1979 production at which time the old heat treat furnace was fully operational. The new furnace is equipped with ceramic liner and a high efficiency burner system. If combustion air preheating is added, the overall energy savings over the 1979 figure should be:

148,306 Therms/Year x 0.56 Icrease in Efficiency = 83,051 Therms/Yr.

Cost Savings (83,051 Therms/Yr. x 0.267) = $22,174.00

The above savings are based on no change in material though put over the 1979 figures.

Without combustion air preheating, the anticipated energy savings over the 1979 figure would be:

148,306 Therms/yr. x 0.33 Increase in Efficiency = 48,941 Therms/yr.

Cost Savings (48,941 Therms/Yr. x 0.267) = $13,067.00

Therefore, additional cost savings by installing recuperator system for combustion air preheating would be:

(22,174 - 13,067) = 9,107 per year

UPGRADING LADLE PREHEATER

Gas consumption per Ladle Heater	=	250 CFH
No. of Ladle Heaters Operating at One Time	=	4 Units
Total Gas Consumption	=	1,000 CFH
Operating Hours 3Hrs/Day - 240 Days/Yr.	=	720 Hrs/Yr.
Annual Gas Consumption (720 x 1,000)	=	7,200 Therms/Yr.

Potential energy savings will be approximately 40% by performing the following changes:

- Installing covers.
- Installing high efficiency burner sytem.
- Installing fiber linings.

Therefore: Energy Savings (7,200 x .4) = 2,880 Therms/Yr.

Cost Savings (2,880 x 0.267) = $769.00 per Yr.

ELECTRICAL ENERGY COST SAVINGS.

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Percentage of total energy usage by electrical load:

$$= \frac{\text{Electrical Energy}}{\text{Total Energy}} = \frac{47{,}194 \times 10^6}{66{,}132 \times 10^6} \times 100 = 71.0\%$$

1/ Melting energy usage at 69% = 13,831,880 x 69%
= 9,544,000 KWH

Based on a sample billing period of one month each at summer and winter rate schedules, the cost reduction potential is:

1. Demand Control

	Summer	Winter	Total
Normal melting cost 2/	$32,237	$36,870	$69,107
Demand limited cost 3/	31,402	36,578	67,980
Reduction			$ 1,127

$$\text{Percent savings} = \frac{1{,}127}{69{,}107} = 1.6\%$$

Therefore, Annual savings

= Melt KWH x Avg. cost/KWH* x Percent savings

= 9,544,000 x 0.06 x 0.016 = $9,160 per year

For graphic illustration of methodology used in calculating electrical savings see Figures 1 and 2.

2. Off-Peak Melting

	Summer	Winter	Total
Normal melting cost 2/	$32,237	$36,870	$69,107
Off-peak melting cost 4/	26,455	34,474	60,929
Total			$ 8,178

$$\text{Percent savings} = \frac{8{,}178}{69{,}107} = 11.8\%$$

Therefore, Annual savings

= Melt. KWH x Avg. cost/KWH* x Percent savings

= 9,544,000 x 0.06 x 0.118 = $67,570 per year

For graphic illustration of methodology used in the calculation of electrical savings see Figures 1 and 4.

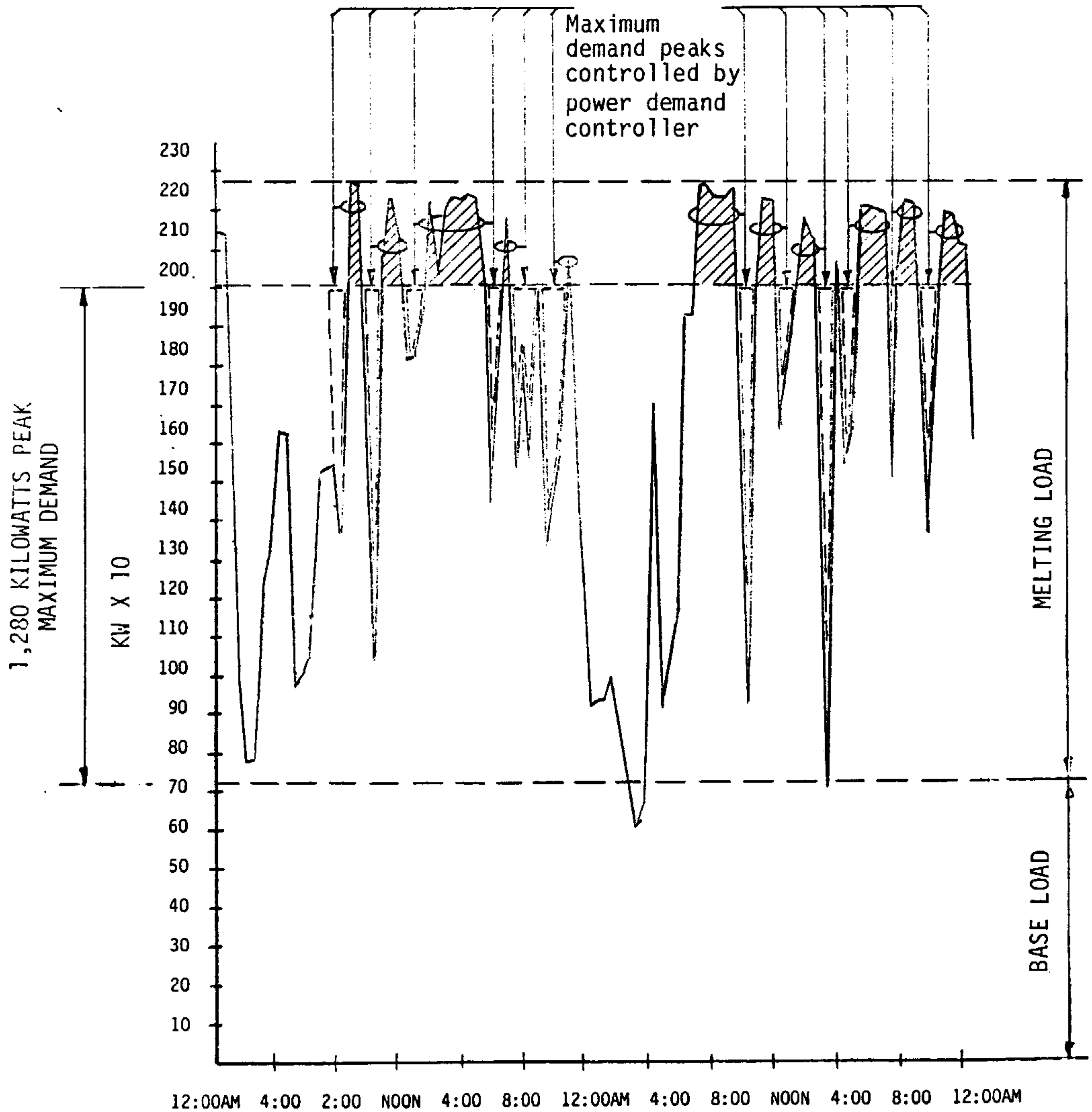
1/ Work sheet Table 1.

2/ Work sheet Table 2.

3/ Work sheet Table 3.

4/ Work sheet Table 4.

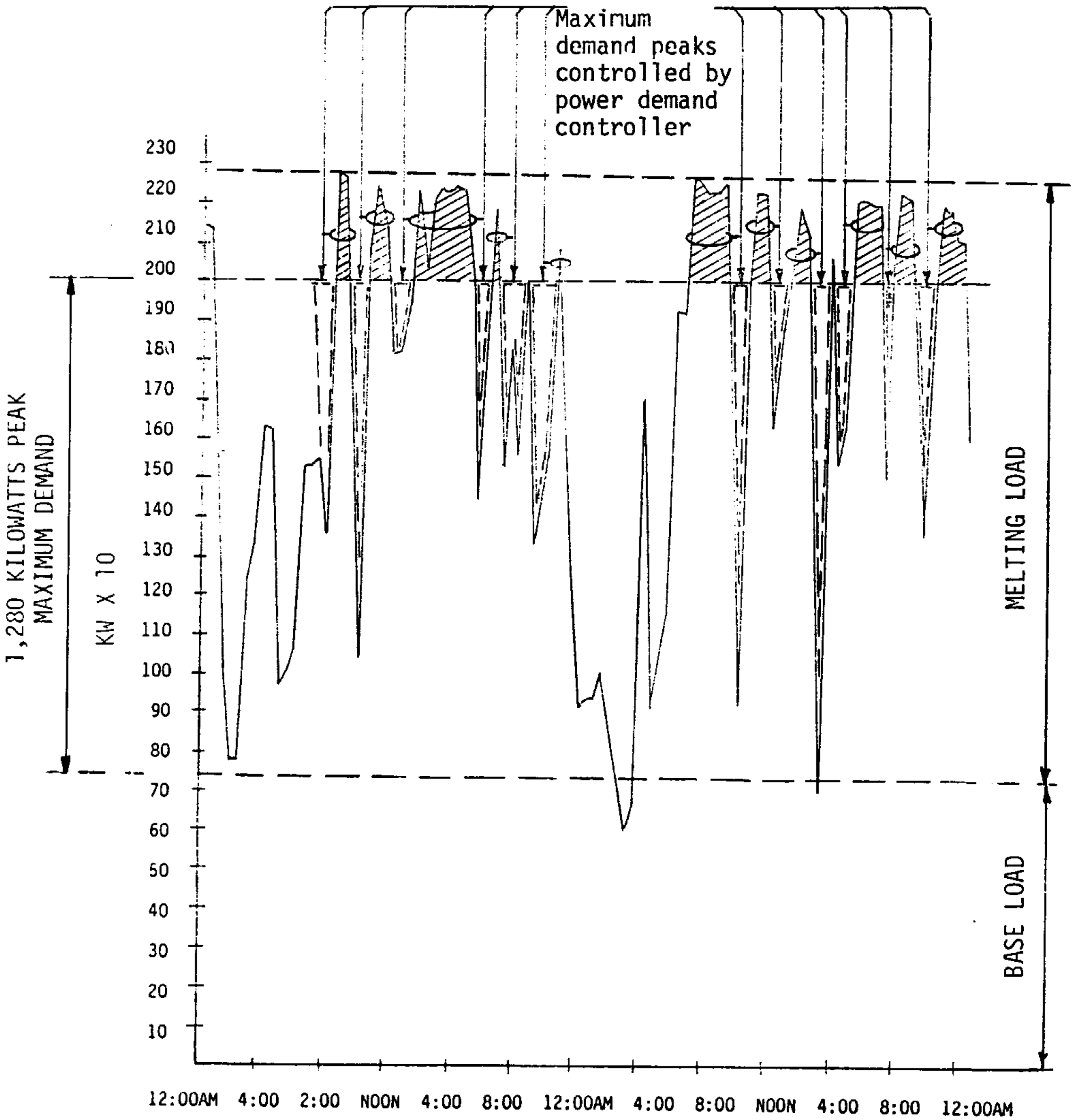
*NOTE: 1980 energy costs used.



SUMMER "TIME OF DAY" BUILLING

KILOWATT DEMAND PROFILE

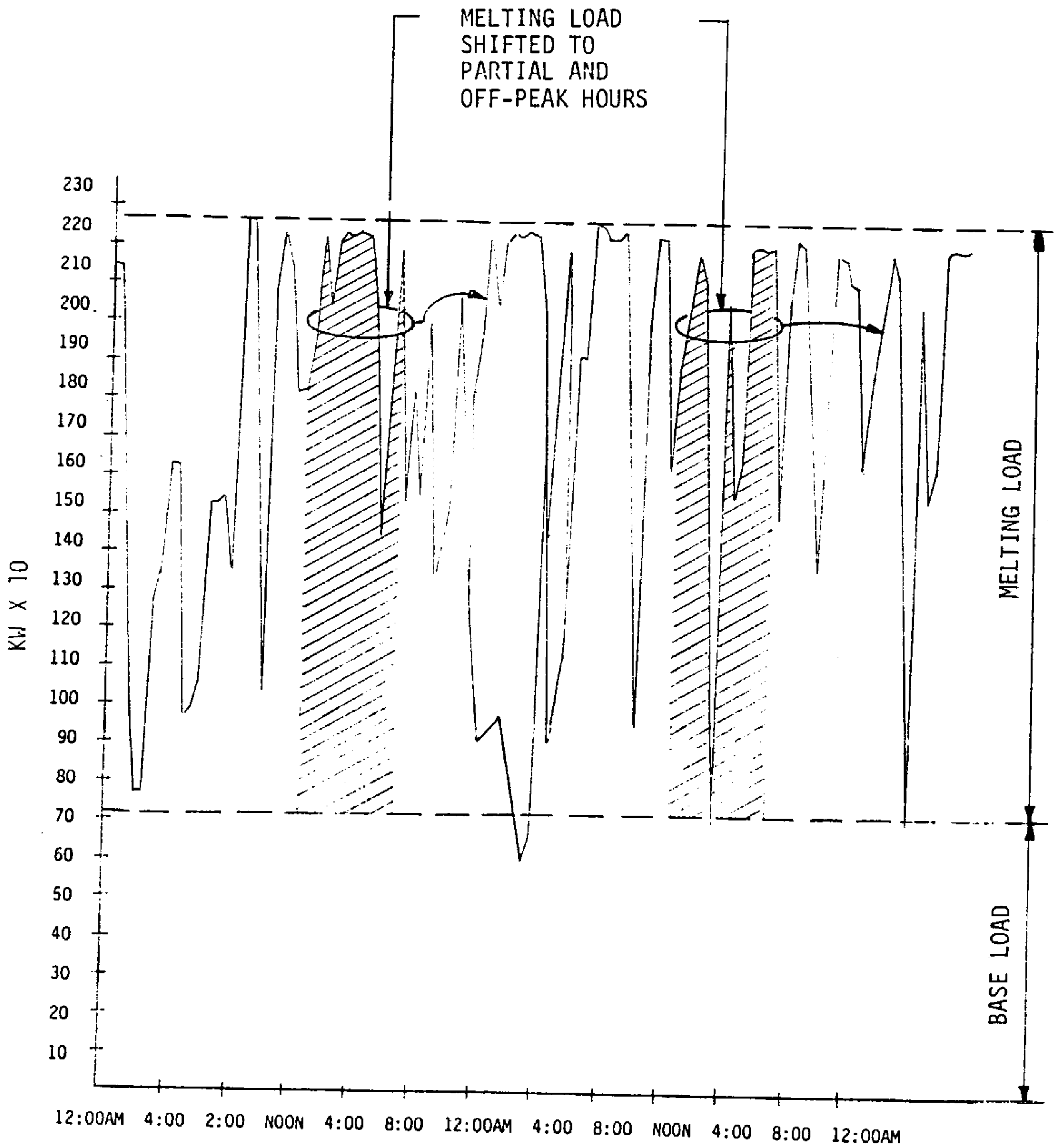
FIGURE 1



WINTER "TIME OF DAY" BULLING

KILOWATT DEMAND PROFILE

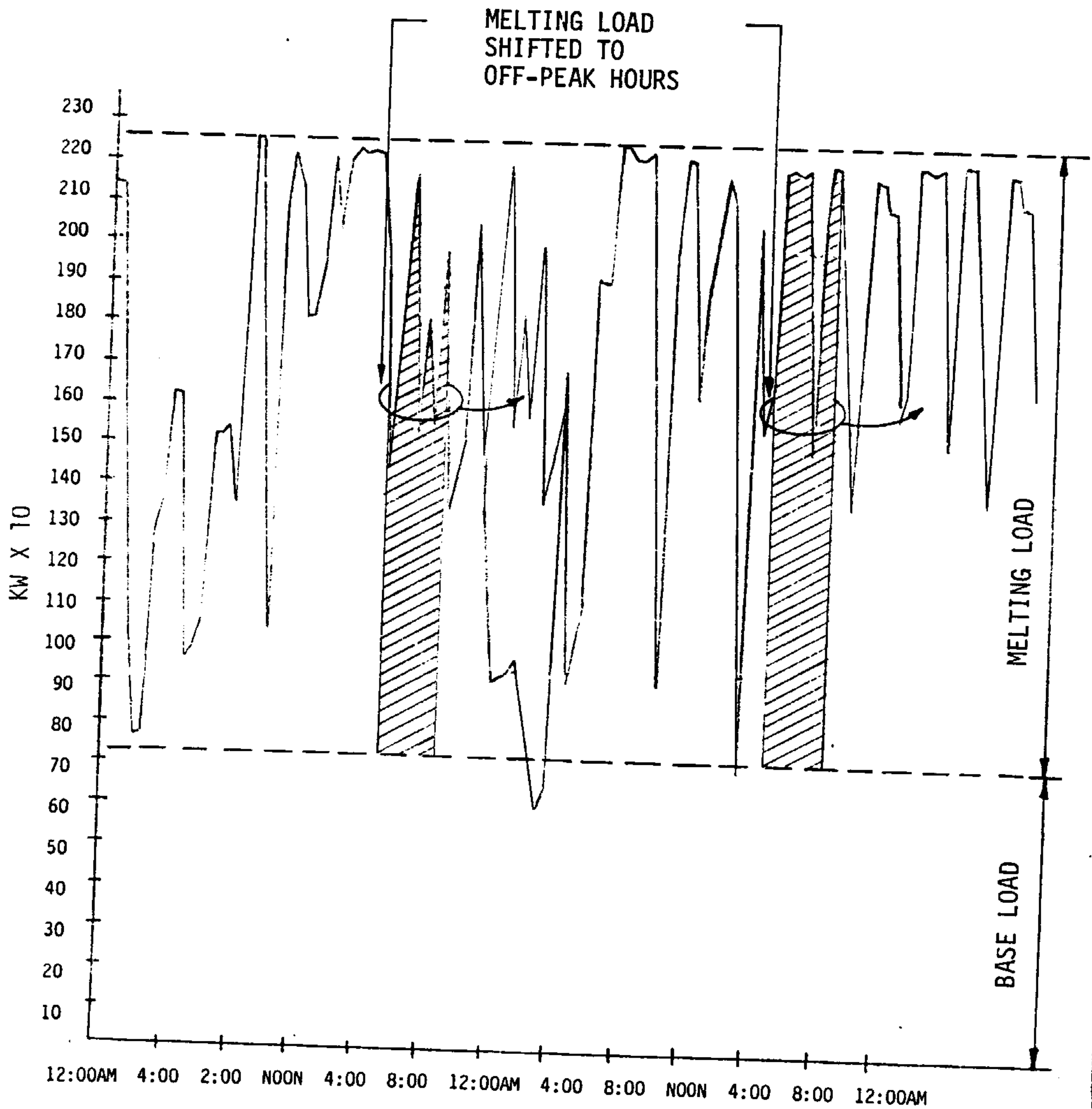
FIGURE 2



SUMMER "TIME OF DAY" BILLING

KILOWATT DEMAND PROFILE

FIGURE 3



WINTER "TIME OF DAY BILLING

KILOWATT DEMAND PROFILE

FIGURE 4

<u>TOTAL MELTING ENERGY</u> (Use actual metered consumption if available or estimate as follows:)

$$\frac{\text{Annual tons shipped}}{\text{Overall Foundry yield \%}} = \text{Total tons melted per year}$$

Total tons melted X average kWh/ton = Total energy

Example:

$$\frac{\text{Annual tons shipped}}{\text{Foundry yield \%}} = \frac{6,405}{0.6} = 10,675$$

Therefore, Tons melted/year X kWh/ton* = 10,605 x 900

= <u>9,544,000</u> KWH

Percent melting energy of total electrical usage

$$= \frac{9,607,500}{13,831,880} = 69\%$$

*Note: kWh/ton determined from actual melt cycle or use industry average for type of furnace and metal melted.

TABLE 1

FOUNDRY "B"

SUMMER NORMAL METLING (69% OF TOTAL)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on-peak 1,579 kW at $ 2.50	$	3,948
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,571 kW at $0.30	$	471
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,565 kW at No Charge	$	0
Subtotal	$	4,419
Energy Charge:		
"On-peak" per kilowatt hour:		
12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 113,608 x ¢0.022/kWh	$	2,499
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm .8 hrs/day		
Total kilowatt hours 167,275 x ¢0.019/kWh	$	3,178
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 211,924 x ¢0.010/kWh	$	2,119
Subtotal	$	7,796
Fuel Adjustment Charges:		
Total kilowatt hours = 492,807 x ¢ 0.04063	$	20,022
GRAND TOTAL for demand, energy and fuel adjustment charges	$	32,237

TABLE 2

FOUNDRY "B"

WINTER NORMAL MELTING
(69% OF TOTAL ELECTRIC ENERGY)

Demand Charges:	
"On-peak" per kilowatt of maximum demand	
Total on-peak 1,555 kW at $0.75	$ 1,166
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 1,624 kW at $0.25	$ 406
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 1,638 kW at No Charge	$ 0
Subtotal	$ 1,572
Energy Charge:	
"On-peak" per kilowatt hour:	
4:30 pm to 8:30 pm 4 hrs/day	
Total kilowatt hours 91,448 x ¢0.019/kWh	$ 1,738
"Partial peak" kilowatt hours:	
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day	
Total kilowatt hours 282,067 x ¢0.014/kWh	$ 3,949
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 285,120 x ¢0.010/kWh	$ 2,851
Subtotal	$ 8,538
Fuel Adjustment Charges:	
Total kilowatt hours = 658,635 x ¢0.04063	$ 26,760
GRAND TOTAL for demand, energy and fuel adjustment charges	$ 36,870

TABLE 2

FOUNDRY "B"

DEMAND LIMITING

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on-peak 1,280 kW at $2.50	$	3,200
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,280 kW at $0.30	$	384
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,280 kW at No Charge	$	0
Subtotal	$	3,584
Energy Charge:		
"On-peak" per kilowatt hour:		
12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 113,608 x ¢0.022/kWh	$	2,499
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm ,8 hrs/day		
Total kilowatt hours 167,275 x ¢0.019/kWh	$	3,178
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 211,924 x ¢0.010/kWh	$	2,119
Subtotal	$	7,796
Fuel Adjustment Charges:		
Total kilowatt hours = 492,807 x ¢0.04063	$	20,022
GRAND TOTAL for demand, energy and fuel adjustment charges	$	31,402

TABLE 3

FOUNDRY "B"

DEMAND LIMITING

Demand Charges:

"On-peak" per kilowatt of maximum demand		
Total on-peak 1,280 kW at $0.75	$	960
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,280 kW at $0.25	$	320
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,280 kW at No Charge	$	0
Subtotal	$	1,280

Energy Charge:

"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 91,448 x ¢0.019/kWh	$	1,738
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 282,067 x ¢0.014/kWh	$	3,949
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 285,120 x ¢0.010/kWh	$	2,851
Subtotal	$	8,538

Fuel Adjustment Charges:

Total kilowatt hours = 658,635 x ¢0.04063	$	26,760
GRAND TOTAL for demand, energy and fuel adjustment charges	$	36,578

TABLE 3

FOUNDRY "B"

OFF-PEAK MELTING (SUMMER)

Demand Charges:

"On-peak" per kilowatt of maximum demand		
Total on-peak 0 kW at $2.50	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 0 kW at $0.30	$	0
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,579 kW at No Charge	$	0
Subtotal	$	0

Energy Charge:

"On-peak" per kilowatt hour:		
12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 0 x ¢0.022/kWh	$	0
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm .8 hrs/day		
Total kilowatt hours 167,275 x ¢0.019/kWh	$	3,178
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 325,532 x ¢0.010/kWh	$	3,255
Subtotal	$	6,433

Fuel Adjustment Charges:

Total kilowatt hours = 492,807 x ¢0.04063	$	20,022
GRAND TOTAL for demand, energy and fuel adjustment charges	$	26,455

TABLE 4

FOUNDRY "B"

OFF-PEAK MELTING (WINTER)

Demand Charges:

"On-peak" per kilowatt of maximum demand		
Total on-peak 0 kW at $0.75	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 0 kW at $0.25	$	0
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,638 kW at No Charge	$	0
Subtotal	$	0

Energy Charge:

"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 0 x ¢0.019/kWh	$	0
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 282,067 x ¢0.014/kWh	$	3,949
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 376,568 x ¢0.010/kWh	$	3,765
Subtotal	$	7,714

Fuel Adjustment Charges:

Total kilowatt hours = 658,635 x ¢0.04063	$	26,760
GRAND TOTAL for demand, energy and fuel adjustment charges	$	34,474

TABLE 4

PART F

ECONOMIC ANALYSIS

Payback period is calculated from

$$\frac{\text{Capital Investment}}{\text{Cost Savings/year}} = \text{years}$$

Payback years for individual projects are listed in Part "G", based on order of magnitude costs as follows:

• Demand controllers	$ 10,000
• Upgrading heat treat furnaces	50,000
• Upgrading ladle heaters	8,000
TOTAL	$ 68,000

The following conditions could lower the anticipated payback period considerably:

- Present day equipment costs used, the energy savings cost is based on 1979 calendar year average energy costs (except for electrical energy costs).

- No credit taken for government tax break for installation of energy saving devices.

- Calculation of return on investment utilizing life-cycle costing methods, which take into account depreciation, cost of money and escalation of energy cost over the lifetime of the equipment, will possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION (ALTERNATE 1)

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD YEAR
Demand controllers		$ 9,160	$ 10,000	1.1
Upgrading heat treat furnaces	8,305	22,170	50,000	2.3
Upgrading ladle heaters	288	770	8,000	10.4
TOTAL	8,593	$32,100	$ 68,000	2.1

TABLE 1

PART G

SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION (ALTERNATE 2)

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD YEAR
Off-peak melting	-	$67,570	-	-
Upgrading heat treat furnaces	8,305	22,170	$ 50,000	2.3
Upgrading ladle heaters	288	770	8,000	10.4
TOTAL	8,593	$90,510	$ 58,000	0.6

TABLE 2

FOUNDRY "B"

PROJECTED ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED				1979/80	
UNITS OF PRODUCTION				6,407 tons	
FUEL COSTS					
• Electricity			$	830,397.00 2/	
• Natural Gas				27,792.00	
• Propane				--	
• Oil				--	
• Coke				--	
• Other				--	
		TOTAL	$	858,189.00	
ENERGY USED					
• KWH	13,831,880	x 3,412 Btu	=	47,194	Btu x 10^6
• Mcf Gas	10,345	x	1/	10,345	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=	--	
• Gal. Oil		x 140,000 Btu	=	--	
• Coke - lb.		x 12,500 Btu	=	--	
•			=	--	
		TOTAL BTU		57,539	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{57{,}539}{6{,}407} = 8.98 \times 10^6/\text{ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{858{,}189}{57{,}539} = \$\ 14.9 \quad \text{Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{858{,}189}{6{,}407 \text{ tons}} = \$\ 133.90 \quad \text{Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ Projected 1980 energy cost.

ALTERNATE 1

TABLE 3

FOUNDRY "B"

PROJECTED ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED		1979/80
UNITS OF PRODUCTION		6,407 tons
FUEL COSTS		
• Electricity	$	771,987.00
• Natural Gas		27,792.00
• Propane		--
• Oil		--
• Coke		--
• Other		--
TOTAL	$	799,779

ENERGY USED

• KWH	13,831,880	x	3,412 Btu	=	47,194	$Btu \times 10^6$
• Mcf Gas	10,345	x		1/	10,345	$Btu \times 10^6$
• Gal. Propane		x	91,600 Btu	=	--	
• Gal. Oil		x	140,000 Btu	=	--	
• Coke - lb.		x	12,500 Btu	=	--	
•				=	--	
			TOTAL BTU		57,539	$Btu \times 10^6$

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{57{,}539}{6{,}407} = 8.98 \times 10^6 \text{ Btu/ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{799{,}779}{57{,}539} = \$\ 13.89 \quad \text{Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{799{,}779}{6{,}407 \text{ tons}} = \$\ 124.82 \quad \text{Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

ALTERNATE 2

TABLE 4

SECTION III

TABLE OF CONTENTS

FOUNDRY "C"

Part "A" General Description

Ductile and Gray Iron castings produced on fine green sand and two chemically bonded molding lines. One shift operation per day, 5 days per week.

Facilities

Building Area	-	Not Available
Manning Total	-	Not Available
Average Shipments	-	2,520 Tons/year
Average Sales Value	-	$8.5 Million

Melt Furnaces

Electric coreless induction 1 x 3,000 lb. (350 KW)
Electric coreless induction 2 x 12,000 lb. (1,500 KW)
2 Cupolas - 72" shell, 48" dia. (used as reserve back-up to electric furnaces)

Equipment

Dry sand and green sand cope and drag molding, 10 lbs. to 200 lbs. average casting weight. No-bake molding with continuous mixer for average 100 lbs. to 1,000 lbs. each casting. Average foundry pouring yield 53%. Core making by chemical and oil sand process methods. Heat treatment is carried out in 2 car bottom furnaces. Cleaning of castings by shot blast and grinders operates 16 hours per day. 1,500 cfm of compressed air is available.

PART B

ENERGY USE TABLES

FOUNDRY "C"

ELECTRICAL POWER USAGE*

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	376,800	2,291	.97	11,570	(638)	5,394	17,602	$ 16,964.00
FEBRUARY 1979	386,400	2,255	.98	10,757	(647)	5,318	16,722	16,075.00
MARCH 1979	367,200	2,279	.99	10,136	(648)	5,361	16,145	15,497.00
APRIL 1979	415,200	N/A	N/A	N/A	N/A	N/A	N/A	16,728.00
MAY 1979	376,800	2,266	.98	10,443	(548)	5,341	16,332	15,784.00
JUNE 1979	376,800	N/A	N/A	N/A	N/A	N/A	N/A	15,900.00
JULY 1979	228,000	2,281	.98	6,646	(450)	5,373	12,469	12,019.00
AUGUST 1979	384,000	2,262	.99	10,748	(476)	5,333	16,557	16,081.00
SEPTEMBER 1979	434,400	2,404	.99	12,117	(509)	5,634	18,260	17,751.00
OCTOBER 1979	432,000	2,443	.98	12,650	(505)	5,717	18,872	18,367.00
NOVEMBER 1979	468,000	2,500	.98	14,149	(521)	5,838	20,508	19,987.00
DECEMBER 1979	427,200	N/A	.99	N/A	(256)	N/A	15,029	14,772.00
TOTALS	4,672,800							$195,925.00

* 12,000 VOLT SERVICE (FURNACES) A-13 SCHEDULE.

AVERAGE ENERGY COST $= \frac{195,962}{4,672,800} =$ \$ 0.041/KWH

TABLE 1

Sheet 1 of 2

FOUNDRY "C"

ELECTRICAL POWER USAGE*

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	160,560	N/A	N/A	N/A	N/A	N/A	N/A	$ 6,615.00
FEBRUARY 1979	161,520							6,253.00
MARCH 1979	157,920							6,099.00
APRIL 1979	160,080							6,121.00
MAY 1979	150,480							5,857.00
JUNE 1979	157,440							6,104.00
JULY 1979	94,080							4,152.00
AUGUST 1979	150,240							5,857.00
SEPTEMBER 1979	155,040							6,035.00
OCTOBER 1979	161,760							6,465.00
NOVEMBER 1979	162,720							6,672.00
DECEMBER 1979	155,280							6,420.00
TOTALS	1,827,120							$72,650.00

* GENERAL PLANT SERVICE - A12 RATE SCHEDULE.

AVERAGE ENERGY COST $= \frac{72,650}{1,827,120} =$ $ 0.039/KWH

COST SUMMARY (ALL SERVICES)

SERVICE	KWH	COST
HIGH VOLTAGE	4,672,800	$ 195,925.00
GENERAL PLANT	1,827,120	72,650.00
TOTALS	6,499,920	$268,575.00

TABLE 1

FOUNDRY "C"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
JANUARY 1979	30,027	3,002.7	$ 7,589.00
FEBRUARY 1979	34,905	3,490.5	8,821.00
MARCH 1979	27,003	2,700.3	6,825.00
APRIL 1979	27,000 1/	2,700.0	6,821.00
MAY 1979	27,945	2,794.5	7,063.00
JUNE 1979	22,739	2,273.9	5,967.00
JULY 1979	15,304	1,530.4	4,298.00
AUGUST 1979	25,946	2,594.6	7,286.00
SEPTEMBER 1979	24,092	2,409.2	6,766.00
OCTOBER 1979	24,058	2,405.8	6,756.00
NOVEMBER 1979	27,600	2,760.0	9,039.00
DECEMBER 1979	30,197	3,019.7	9,776.00
TOTALS	316,816	31,681.6	$ 87,007.00

1/ NO INFORMATION - ASSUMED VALUE.

HEAT CONTENT OF GAS = BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{87,007}{316,816}$ = $ 0.274 PER THERM

NOTE: From December 1979 through May 1980 - 6 months
Average gas cost increased to $ 0.396 PER THERM.

TABLE 2

FOUNDRY "C"

ANNUAL COKE CONSUMPTION

PERIOD	TONS	BTU X 10^6	COST
JANUARY 1979	NONE	---	----
FEBRUARY 1979	NONE	---	----
MARCH 1979	5.0	125	1,030*
APRIL 1979	NONE	---	----
MAY 1979	NONE	---	----
JUNE 1979	NONE	---	----
JULY 1979	5.0	125	1,030
AUGUST 1979	5.0	125	1,030
SEPTEMBER 1979	NONE	---	----
OCTOBER 1979	NONE	---	----
NOVEMBER 1979	NONE	---	----
DECEMBER 1979	NONE	---	----
TOTALS	15.00	375	$ 3,090

AVERAGE COKE COST = ASSUMED $206/TON

NOTE:

Cupola #1 - 72-inch acid lined to 48-inch.
Interm. tapped in 1,500# taps.
Typical melt program - 30,000# to 50,000# per day, one day per month. Used as reserve backup to electric furnaces.

Cupola #2 - Same as #1 except basic lined.

TABLE 3

FOUNDRY "C"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	SERVICE
MELTING DEPARTMENT							
FURNACE #1	CORELESS INDUCTION	3,000#				350	
FURNACE #2	CORELESS INDUCTION	12,000#				1,500	
FURNACE #3	CORELESS INDUCTION	12,000#				1,500	

TABLE 4

FOUNDRY "C"

DESCRIPTION AND FLOW RATES OF GAS FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
HEAT TREAT #1	BOTTOM FURNACE	16	N/A	N/A	N/A	N/A	N/A
HEAT TREAT #2	BOTTOM FURNACE	N/A	N/A	N/A	N/A	N/A	N/A
LADLE HEATERS (A)		3	TORCH TYPE	9.5	21	N/A	750*
LADLE HEATERS (B)		2	TORCH TYPE	4	21	N/A	500*
LADLE HEATERS (C)		1	TORCH TYPE	6	17	N/A	200*
LADLE HEATERS (D)		2	TORCH TYPE	6	12	N/A	400*
TOTALS							

* ESTIMATED

TABLE 5

FOUNDRY "C"

1979 ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED	1979	
UNITS OF PRODUCTION	2,520	
	NET GOOD TONS PER YEAR	
FUEL COSTS		
• Electricity	$ 268,575.00	
• Natural Gas	87,007.00	
• Propane	----	
• Oil	----	
• Coke	3,090.00	
• Other	----	
TOTAL	358,672.00	

ENERGY USED

• KWH	6,499,920	x	3,412 Btu	=	22,177.7	Btu x 10^6
• Mcf Gas	31,681			1/	31,681	Btu x 10^6
• Gal. Propane	----	x	91,600 Btu	=	----	
• Gal. Oil	----	x	140,000 Btu	=	----	
• Coke - lb.	30,000	x	12,500 Btu	=	375	Btu x 10^6
•				=	----	
			TOTAL BTU		54,233	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}\ 54,233}{\text{(Units)}\ 2,520}$ = 21.52 Btu x 10^6/TON

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}\ 358,672}{\text{(Million Btu)}\ 54,233}$ = 6.61 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}\ 358,672}{\text{(Units)}\ 2,520}$ = 142.3 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 6

FOUNDRY "C"

ENERGY-EFFICIENCY RECORD 2/3/

MONTH OR YEAR RECORDED			1980 Projected (Electrical Only)	
UNITS OF PRODUCTION			2,520	
			NET GOOD TONS PER YEAR	
FUEL COSTS				
• Electricity		$	425,700.00	
• Natural Gas			87,007.00	
• Propane			None	
• Oil			None	
• Coke			3,090.00	
• Other			----	
	TOTAL		515,797.00	

ENERGY USED

• KWH	6,499,920	x 3,412 Btu	=	22,177.7	Btu x 10^6
• Mcf Gas	31,681		1/	31,681	Btu x 10^6
• Gal. Propane	----	x 91,600 Btu	=	----	
• Gal. Oil	----	x 140,000 Btu	=	----	
• Coke - lb.	30,000	x 12,500 Btu	=	375	Btu x 10^6
•			=	----	
		TOTAL BTU		54,233	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}\quad 54,233}{\text{(Units)}\quad 2,520} = 21.52 \text{ Btu} \times 10^6/\text{TON}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}\quad 515,797}{\text{(Million Btu)}\quad 54,233} = 9.51 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}\quad 515,797}{\text{(Units)}\quad 2,520} = 204.68 \text{ Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with "time of day" billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of "off-peak" melting and demand control.

3/ All other energy costs are 1979 rates.

TABLE 7

PART C

PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE C

CASTING METAL G & D.I.

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	350	N/A	N/A	N/A
FEBRUARY	350			
MARCH	375			
APRIL	460			
MAY	350			
JUNE	350			
JULY	305			
AUGUST	375			
SEPTEMBER	460			
OCTOBER	460			
NOVEMBER	480			
DECEMBER	460			
TOTALS	4,775	2,520		$8,000,000

AVERAGE MELT TONS/DAY = 25

REPORTED % SCRAP N/A

REPORTED % MELT LOSS N/A

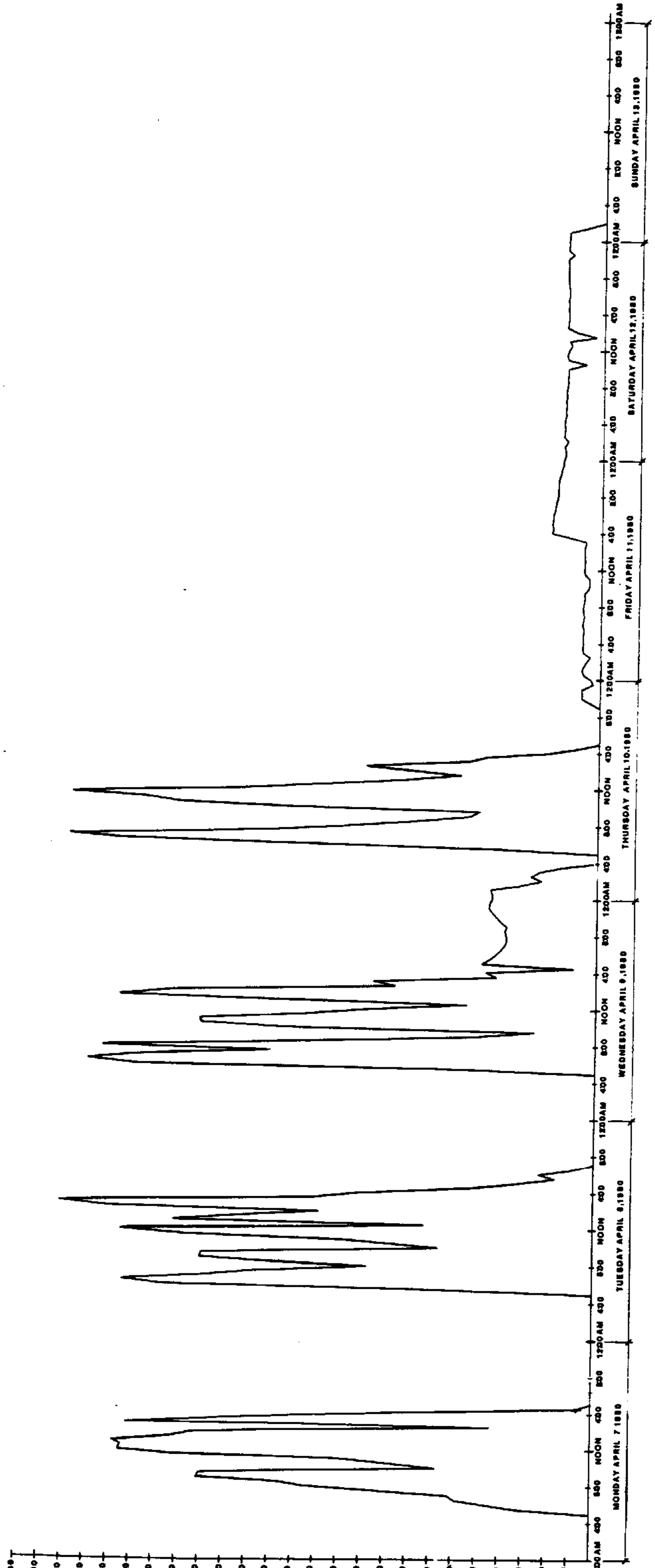
AVERAGE FOUNDRY YIELD % 52.7%

AVERAGE SALES VALUE/LB. ______

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE (WINTER)
INDUCTION FURNACES

FOUNDRY C

FIGURE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

FURNACE NO. 1

Furnace make N/A Transformer KVA N/A

Model 350 kW 180 HZ Primary Voltage N/A

Capacity 3,000 # Secondary Voltage N/A

Output 640 tons/yr.

3 tons/day

Alloy Gray Iron, Ductile

Melt cycle N/A minutes

Tap Quantity 800 # to 1,500' lbs.

Charge Quantity N/A lbs.

Tap temperature 2,820 ^oF

Holding temperature 1,600 ^oF

Slag cycle N/A minutes

Fume collection ____ CFM

Water cooling N/A. GPM, Temp N/A. in ^oF N/A. Out ^oF

Type of Refractory N/A

Energy consumption 636,288 KWH/YR

Energy Cost 4.1 ¢/KWH

TABLE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

FURNACE NO. 2

Furnace make N/A Transformer KVA N/A

Model 1,500 KW 60 HZ Primary Voltage N/A

Capacity 12,000 # Secondary Voltage N/A

Output 2,030 tons/yr.

10 tons/day

Alloy Gray Iron, Ductile

Melt cycle N/A minutes

Tap Quantity 800 to 6,000 # lbs.

Charge Quantity N/A lbs.

Tap temperature 2,820 ^{o}F

Holding temperature N/A ^{o}F

Slag cycle N/A minutes

Fume collection N/A CFM

Water cooling N/A. GPM, Temp N/A in ^{o}F N/A. Out ^{o}F

Type of Refractory N/A

Energy consumption 2,018,266 KWH/YR

Energy Cost 4.1 ¢/KWH

TABLE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

FURNACE NO. 3

Furnace make N/A

Transformer KVA N/A

Model 1,500 KW 60 HZ

Primary Voltage N/A

Capacity 12,000

Secondary Voltage N/A

Output 2,030 tons/yr.

10 tons/day

Alloy Gray Iron, Ductile

Melt cycle N/A minutes

Tap Quantity 800 to 6,000 lbs.

Charge Quantity N/A lbs.

Tap temperature 2,820 ^{o}F

Holding temperature N/A ^{o}F

Slag cycle N/A minutes

Fume collection N/A CFM

Water cooling N/A. GPM, Temp N/A. in ^{o}F .N/A Out ^{o}F

Type of Refractory N/A

Energy consumption 2,018,226 KWH/YR

Energy Cost 4.1 ¢/KWH

TABLE 1

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES

HEAT TREATING UNIT NO. 1

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL BATCH TYPE	MODEL N/A
SIZE 8' x 10' x 18'	TYPE PREMIX. SIZE N/A BTU/HR
CAPACITY 30,000 LBS.	FUEL NATURAL GAS
TYPE OF LINING CONVENTIONAL	RECUPERATOR MAKE NONE
WALL THICKNESS 9" * INCH	MODEL - TEMP - °F
BLOWER MAKE N/A	TYPE - SIZE -
MODEL N/A	CONTROLS MAKE -
SIZE - CFM. PRESS - "WG	TYPE -
VOLT - HP -	
TYPE OF HEAT TREAT CYCLE 12 to 24 HOUR	ALLOY
HEAT TREAT CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
-COOL DOWN N/A HRS	SHELL MEAN TEMPERATURE N/A °F
CYCLES PER WEEK N/A	FURNACE PRESSURE N/A "WC
TEMPERATURE 1,700 °F	
AVERAGE LOAD 30,000 LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH - AIR, - H2O - OIL	N/A % CO_2
QUENCH TEMPERATURE - °F	FUEL CONSUMPTION 750 THERMS/CYCLE

WALL AREA N/A SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE N/A °F

EXTERNAL SURFACE AREA N/A SQ.FT.

ENERGY COST/THERM $ 0.274

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

* ADDED 3-1/2" CERAMIC FIBER LINING IN JULY 1980

TABLE 2

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES

HEAT TREATING UNIT NO. 2	
FURNACE MAKE N/A	BURNER MAKE N/A
MODEL BATCH TYPE	MODEL N/A
SIZE 7' x 7' x 8'	TYPE N/A SIZE N/A BTU/HR
CAPACITY N/A LBS.	FUEL NATURAL GAS
TYPE OF LINING FIRE BRICK	RECUPERATOR MAKE NONE
WALL THICKNESS 4.5 INCH	MODEL - TEMP - °F
BLOWER MAKE N/A	TYPE - SIZE -
MODEL N/A	CONTROLS MAKE -
SIZE - CFM. PRESS - "WG	TYPE -
VOLT - HP -	
TYPE OF HEAT TREAT CYCLE 12 to 24 HOURS	ALLOY
HEAT TREAT CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
-COOL DOWN N/A HRS	SHELL MEAN TEMPERATURE N/A °F
CYCLES PER WEEK N/A	FURNACE PRESSURE N/A "WC
TEMPERATURE 1,700 °F	
AVERAGE LOAD N/A LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH - AIR, - H2O - OIL	N/A % CO_2
QUENCH TEMPERATURE - °F	FUEL CONSUMPTION N/A THERMS/CYCLE

WALL AREA N/A SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE N/A °F

EXTERNAL SURFACE AREA N/A SQ.FT.

ENERGY COST/THERM $ 0.274

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

TABLE 2

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

OPERATION (A)

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	5:30 AM to 3:00 PM
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	NO	TYPE OF LINING	CONVENTIONAL
INSIDE TEMP	N/A °F	OUTER SHELL TEMP	N/A °F
AMBIENT TEMP	VARIES °F		
GAS USAGE/HR	250 * CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A °F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	NONE	RECUPERATOR EFFCY	NONE
FUEL COST/THERM $	0.274	ANNUAL USE	1781 * BTU x 10^6
NUMBER OF UNITS IN USE	THREE		

* ESTIMATED

TABLE 3

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

OPERATION (B)

LADLE CAP TONS N/A HEAT CYCLES/DAY 4 HOURS

LADLE AREA INSIDE N/A SQ FT. LINING THICKNESS N/A

COVERED NO TYPE OF LINING CONVENTIONAL

INSIDE TEMP N/A ^{o}F OUTER SHELL TEMP N/A ^{o}F

AMBIENT TEMP VARIES ^{o}F

GAS USAGE/HR 250 * CU FT. CO_2 READING N/A

COMBUSTION AIR N/A CFM PRESSURE N/A WG

PREHEAT CYCLE TIME N/A HRS FLUE TEMP N/A ^{o}F

REFRACTORY K VALUE N/A RS VALUE N/A

BLOWER HP NONE RECUPERATOR EFFCY NONE

FUEL COST/THERM $ 0.274 ANNUAL USE 480 * BTU x 10^6

NUMBER OF UNITS IN USE TWO

* ESTIMATED

TABLE 3

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

OPERATION (C)

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	6 HOURS
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	NO	TYPE OF LINING	N/A
INSIDE TEMP	N/A °F	OUTER SHELL TEMP	N/A °F
AMBIENT TEMP	VARIES °F		
GAS USAGE/HR	200 * CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A °F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	NONE	RECUPERATOR EFFCY	NONE
FUEL COST/THERM $	0.274	ANNUAL USE	230 * BTU x 10^6
NUMBER OF UNITS IN USE	ONE		

* ESTIMATED

TABLE 3

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

OPERATION (D)

LADLE CAP TONS	4,000 #	HEAT CYCLES/DAY	N/A
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	NO	TYPE OF LINING	CONVENTIONAL
INSIDE TEMP	N/A °F	OUTER SHELL TEMP	N/A °F
AMBIENT TEMP	VARIES °F		
GAS USAGE/HR	200 * CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	6 HOURS HRS	FLUE TEMP	N/A °F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	NONE	RECUPERATOR EFFCY	NONE
FUEL COST/THERM $	0.274	ANNUAL USE	340 * BTU x 10^6
NUMBER OF UNITS IN USE	TWO		

* ESTIMATED

TABLE 3

OPERATIONAL DATA FACT SHEET

CUPOLA DATA

CUPOLA DIA SHELL	72 INS	REFRACTORY THICKNESS	12"	
LINING	N/A INS	WATER COOLING GPM	NONE	
HEIGHT OF TUYERES ABOVE HEARTH	N/A INS			
LAUNDER LENGTH	N/A	WIDTH	N/A	
METAL TO COKE RATIO	3:1	BED COKE	N/A LBS	
MELT RATE	5 TONS TPH	COKE ADDITION/HR	N/A LBS	
BLAST RATE	NONE CFM	PRESSURE	N/A ONZ	
NUMBER OF ROWS OF TUYERES	N/A	SPACING	N/A	
COOLING WATER USAGE	NONE GPM	$T_1 - T_2$	NOT APPLICABLE ^{o}F	
FAN HP	N/A	MISC. HP	N/A	
HOT BLAST TEMP	NONE ^{o}F	RECUPERATOR CAP	NONE BTU/HR	
AFTER BURNER RATING BTU/HR	NONE			
OXYGEN ENRICHMENT PERCENT ADDITION	NONE %			
MELTING PERIOD; BLAST ON	N/A	BLAST OFF	N/A	
COKE BREEZE ADDITION, PERCENT OF COKE	NONE %			
ANTHRACITE ADDITION, PERCENT OF COKE	NONE %			

TABLE 4

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15- to 30-minute periods.

ELECTRICAL ENERGY COST SAVINGS

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Based on a sample billing period of one month each at summer and winter rate schedules, the cost reduction potential is:

1. Demand Control

	Summer	Winter	Total
Normal melting cost[1/]	$19,414	$20,772	$40,186
Demand limited cost[2/]	19,029	20,596	39,625
Reduction			$ 561

$$\text{Percent savings} = \frac{\text{reduction in cost}}{\text{normal cost of melting}} = 1.4\%$$

Therefore, annual savings;

= Melt KWH x Avg. Cost/KWH* x Percent Savings

= 4,672,800 x .066 x .014 = 4,317/year

For graphic illustration of methodology used in calculating electrical savings see Figures 1 and 2.

2. Off-Peak Melting

	Summer	Winter	Total
Normal melting cost	$19,414	$20,772	$40,186
Off-peak melting cost[3/]	13,752	18,472	32,224
Total			$ 7,962

$$\text{Percent savings} = \frac{7,962}{40,186} = 19.8\%$$

Therefore, annual savings;

= Melt KWH/Yr x Avg. Cost/KWH* x Percent Savings

= 4,672,800 x .066 x .198 = 61,064/year

For graphic illustration of methodology used in the calculation of electrical savings see Figures 3 and 4.

*Note: 1980 energy costs used.

[1/] Work sheet - Table 1.

[2/] Work sheet - Table 2.

[3/] See Table 3.

3. Demand Limiting and Load Shifting

	Summer	Winter	Total
Normal melting cost	$19,414	$20,772	$40,186
Revised melting cost[4/]	15,214	19,535	34,749
Total			$ 5,437

Percent savings = $\frac{5,437}{40,186}$ = 13.5%

Therefore, annual savings;

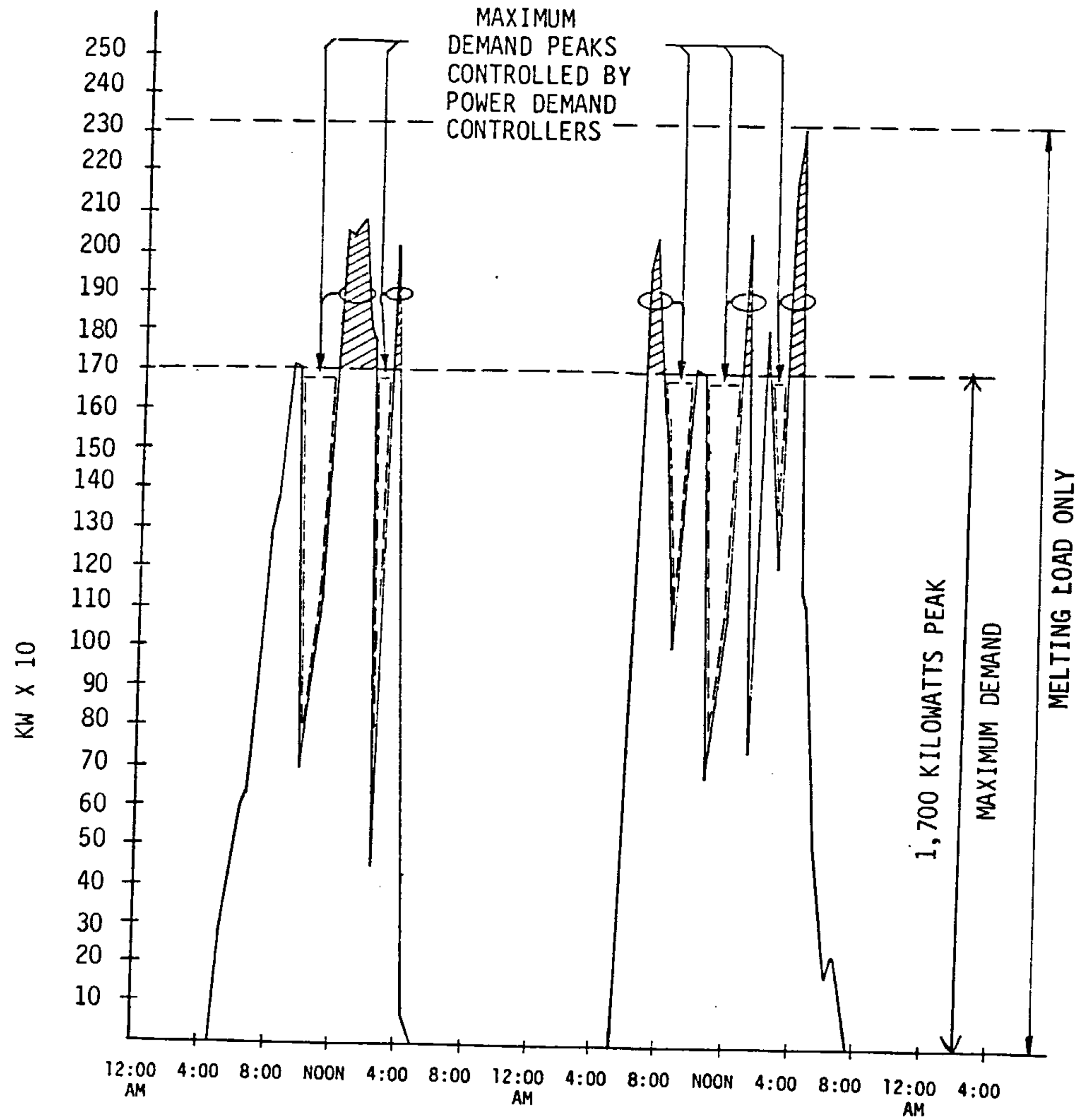
= Melt KWH/Yr x Avg. Cost/KWH* x Percent Savings

= 4,672,800 x .066 x .135 = 41,634/year

For graphic illustration of methodology used in the calculations of electrical savings see Figures 5 and 6.

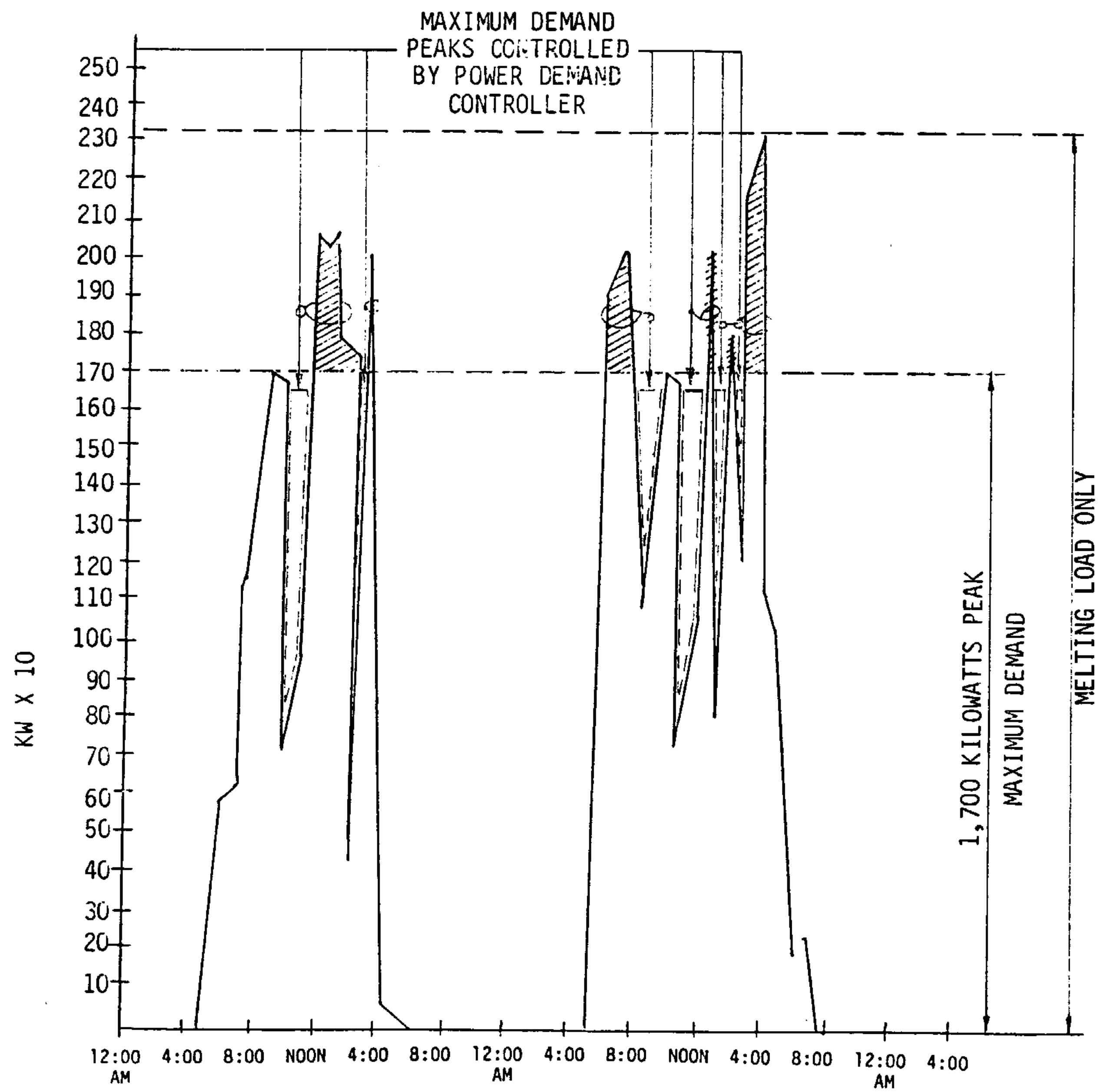
*Note: 1980 energy costs used.

[4/]See Table 4.



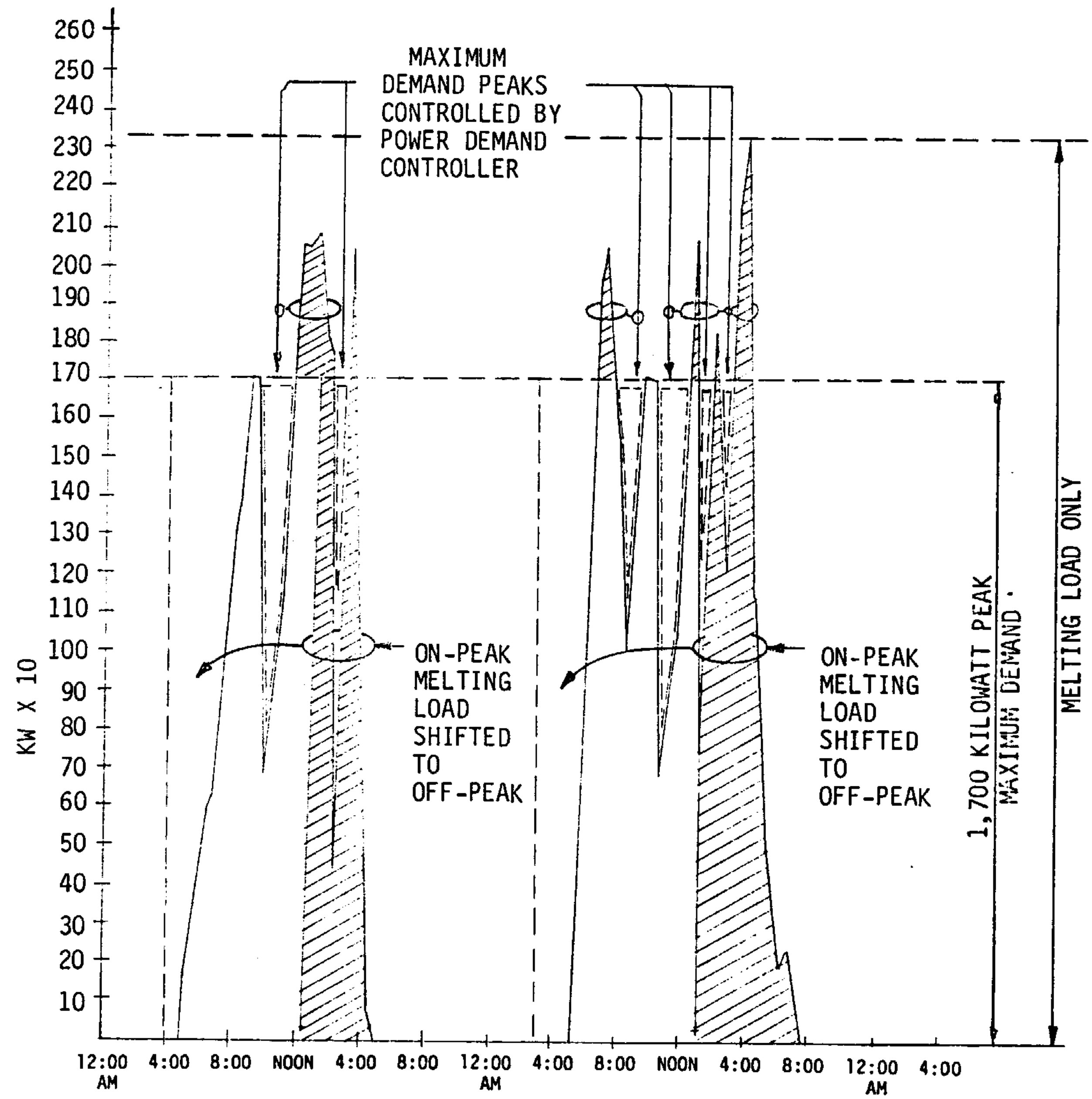
SUMMER-"TIME OF DAY" BILLING
KILOWATT LOAD PROFILE

FIGURE 1



WINTER-"TIME OF DAY" BILLING
KILOWATT LOAD PROFILE

FIGURE 2



SUMMER-"TIME OF DAY" BILLING
KILOWATT LOAD PROFILE

FIGURE 3

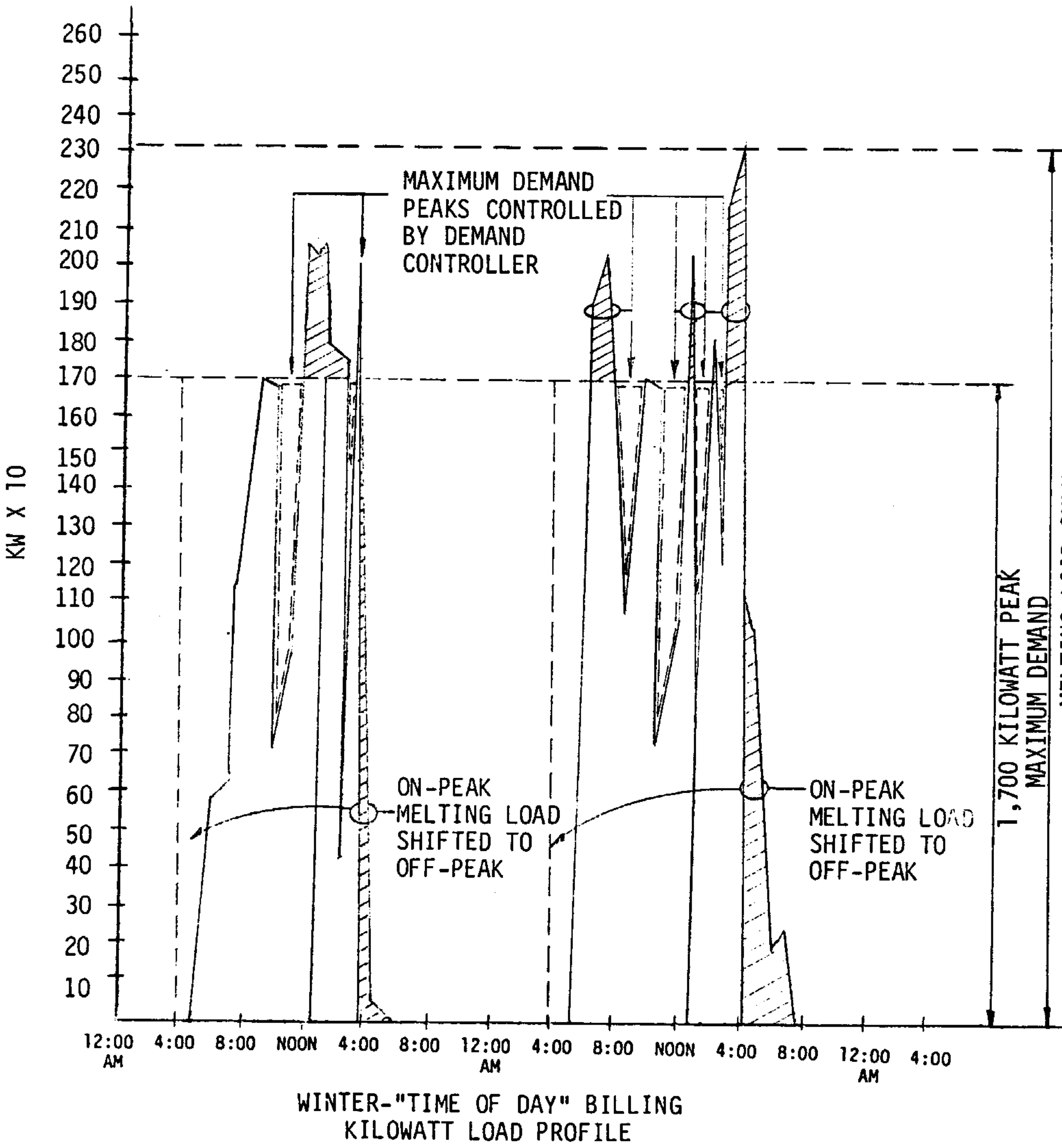
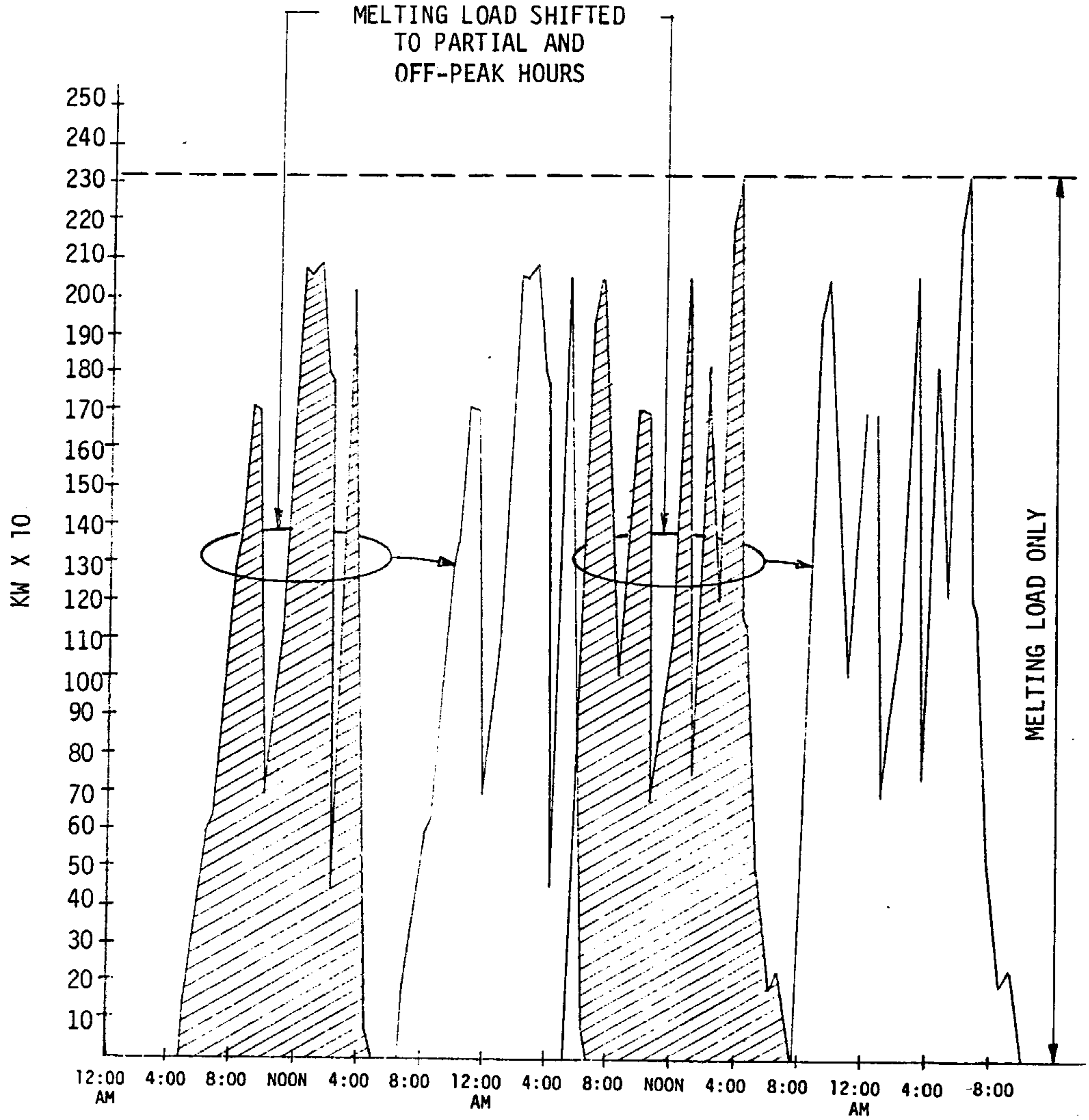
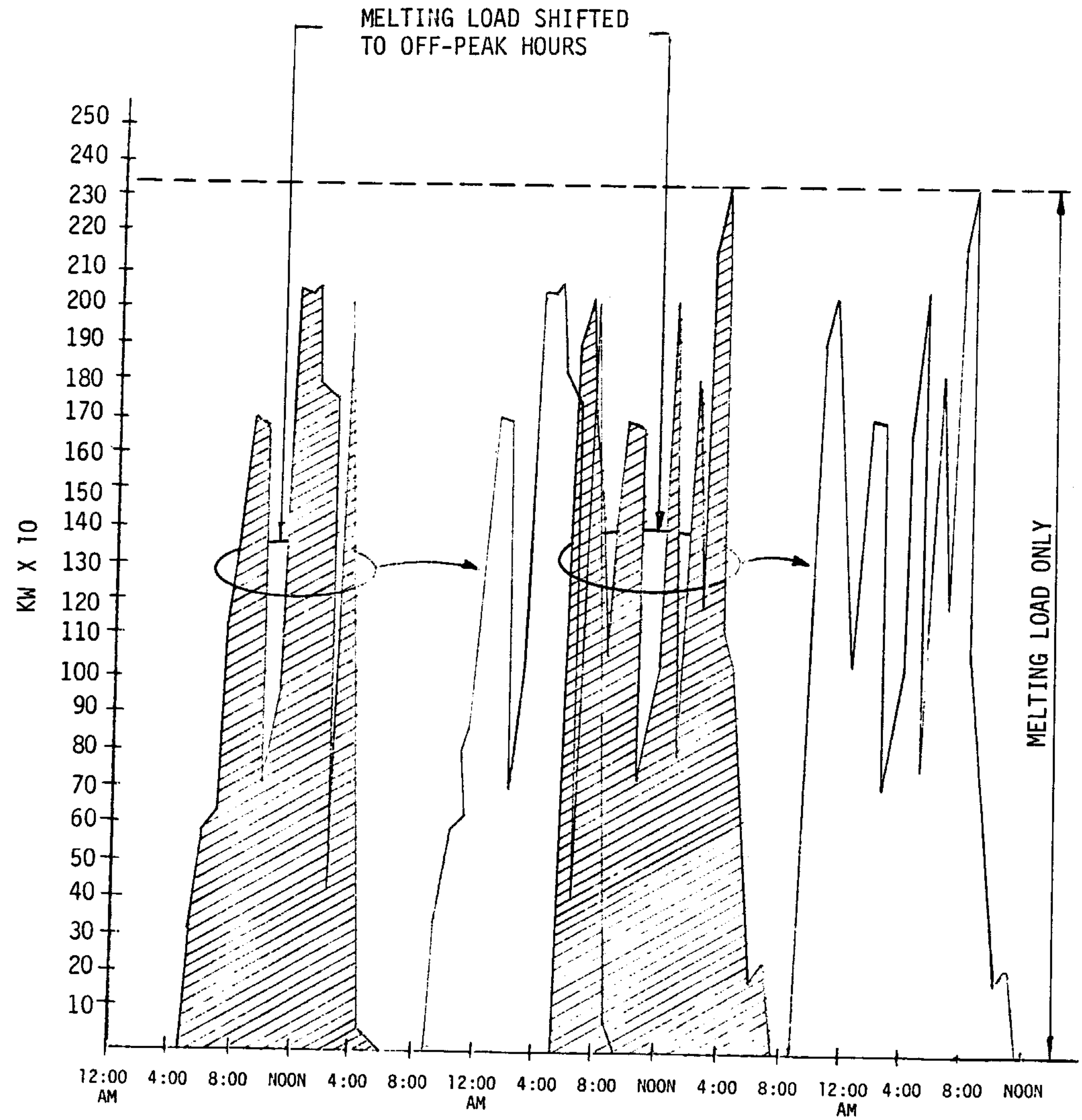

KW X 10
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
MAXIMUM DEMAND
PEAKS CONTROLLED
BY DEMAND
CONTROLLER
ON-PEAK
MELTING LOAD
SHIFTED TO
OFF-PEAK
ON-PEAK
MELTING LOAD
SHIFTED TO
OFF-PEAK
1,700 KILOWATT PEAK
MAXIMUM DEMAND
MELTING LOAD ONLY
12:00 AM
4:00
8:00
NOON
4:00
8:00
12:00 AM
4:00
8:00
NOON
4:00
8:00
12:00 AM
4:00
WINTER-"TIME OF DAY" BILLING
KILOWATT LOAD PROFILE

FIGURE 4



SUMMER-"TIME OF DAY" BILLING
KILOWATT LOAD PROFILE

FIGURE 5



WINTER-"TIME OF DAY" BILLING
KILOWATT LOAD PROFILE

FIGURE 6

SUMMER NORMAL DAYTIME MELTING

Demand Charges:

"On-peak" per kilowatt of maximum demand	
Total on peak 1,466 kW at $ 2.50	$ 3,665
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 2,985 kW at $ 0.30	$ 895
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 3,422 kW no charge	$ 0
Subtotal	$ 4,560

Energy Charge:

"On-peak" per kilowatt hour:	
12:30 pm to 6:30 pm hrs/day	
Total kilowatt hours 50,344 x ¢ 0.022/kwh	$ 1,107
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm	
and 6:30 pm to 10:30 pm .8 hrs/day	
Total kilowatt hours 95,159 x ¢ 0.019/kwh	$ 1,808
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 119,071 x ¢ 0.010/kwh	$ 1,190
Subtotal	$ 4,105

Fuel Adjustment Charges:

Total kilowatt hours = 264,574 x ¢ 0.04063	$ 10,749
GRAND TOTAL for (demand, energy and fuel adjustment charges	$ 19,414

TABLE 1

WINTER NORMAL DAYTIME MELTING

Demand Charges:	
"On-peak" per kilowatt of maximum demand	
Total on peak 1,305 kW at $ 0.75	$ 978
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 2,407 kW at $ 0.25	$ 601
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 2,392 kW no charge	$ 0
Subtotal	$ 1,579
Energy Charge:	
"On-peak" per kilowatt hour:	
4:30 pm to 8:30 pm 4 hrs/day	
Total kilowatt hours 16,661 x ¢ 0.019/kwh	$ 316
"Partial peak" kilowatt hours:	
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day	
Total kilowatt hours 197,009 x ¢ 0.014/kwh	$ 2,758
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 146,901 x ¢ 0.010	$ 1,469
Subtotal	$ 4,543
Fuel Adjustment Charges:	
Total kilowatt hours = 360,571 x ¢ 0.04063	$ 14,650
GRAND TOTAL for (demand, energy and fuel adjustment charges	$ 20,772

TABLE 1

WINTER NORMAL DAYTIME MELTING WITH DEMAND LIMITING

Demand Charges:

"On-peak" per kilowatt of maximum demand		
Total on peak 1,305 kW at $ 0.75	$	978
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,700 kW at $ 0.25	$	425
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,700 kW no charge	$	0
Subtotal	$	1,403

Energy Charge:

"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 16,661 x ¢ 0.019/kwh	$	316
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 197,009 x ¢ 0.014/kwh	$	2,758
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 146,901 x ¢ 0.010	$	1,469
Subtotal	$	4,543

Fuel Adjustment Charges:

Total kilowatt hours = 360,571 x ¢ 0.04063	$	14,650
GRAND TOTAL for (demand, energy and fuel adjustment charges	$	20,596

TABLE 2

SUMMER NORMAL DAYTIME MELTING WITH DEMAND LIMITING

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 1,466 kW at $ 2.50	$	3,665
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,700 kW at $ 0.30	$	510
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,700 kW no charge	$	0
Subtotal	$	4,175
Energy Charge:		
"On-peak" per kilowatt hour:		
12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 50,344 x ¢ 0.022/kwh	$	1,107
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm .8 hrs/day		
Total kilowatt hours 95,159 x ¢ 0.019/kwh	$	1,808
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 119,071 x ¢ 0.010/kwh	$	1,190
Subtotal	$	4,105
Fuel Adjustment Charges:		
Total kilowatt hours = 264,574 x ¢ 0.04063	$	10,749
GRAND TOTAL for (demand, energy and fuel adjustment charges	$	19,029

TABLE 2

SHIFT TO OFF-PEAK AND PARTIAL PEAK (SUMMER)

Demand Charges:			
"On-peak" per kilowatt of maximum demand			
Total on peak	0	kW at $ 2.50	$ 0
Plus "partial peak" per kilowatt of maximum demand			
Total partial peak	0	kW at $ 0.30	$ 0
Plus "off-peak" per kilowatt of maximum demand			
Total "off-peak"	3,422	kW no charge	$ 0
Subtotal			$ 0
Energy Charge:			
"On-peak" per kilowatt hour:			
12:30 pm to 6:30 pm hrs/day			
Total kilowatt hours	0	x ¢ 0.022/kwh	$ 0
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm			
and 6:30 pm to 10:30 pm 8 hrs/day			
Total kilowatt hours	39,686	x ¢ 0.019/kwh	$ 754
"Off-peak" kilowatt hours:			
10:30 pm to 8:30 am 10 hrs/day			
Total kilowatt hours	224,888	x ¢ 0.010/kwh	$ 2,249
Subtotal			$ 3,003
Fuel Adjustment Charges:			
Total kilowatt hours =	264,574	x ¢ 0.04063	$ 10,749
GRAND TOTAL for (demand, energy and fuel adjustment charges			$ 13,752

TABLE 3

SHIFT TO OFF-PEAK AND PARTIAL PEAK (WINTER)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 0 kW at $ 0.75	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 0 kW at $ 0.25	$	0
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 2,392 kW no charge	$	0
Subtotal	$	0
Energy Charge:		
"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 0 x ¢ 0.019/kwh	$	0
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 54,086 x ¢0.014/kwh	$	757
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 306,485 x ¢0.010/kwh	$	3,065
Subtotal	$	3,822
Fuel Adjustment Charges:		
Total kilowatt hours = 360,571 x ¢0.04063	$	14,650
GRAND TOTAL for (demand, energy and fuel adjustment charges	$	18,472

TABLE 3

SHIFT FROM ON-PEAK TO PARTIAL PEAK
WITH DEMAND LIMITING (SUMMER)

Demand Charges:

"On-peak" per kilowatt of maximum demand

Total on peak 0 kW at $ 2.50	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,700 kW at $ 0.30	$	510
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,700 kW no charge	$	0
Subtotal	$	510

Energy Charge:

"On-peak" per kilowatt hour:

12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 0 x ¢ 0.022/kwh	$	0
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm and 6:30 pm to 10:30 pm .8 hrs/day		
Total kilowatt hours 145,503 x ¢ 0.019/kwh	$	2,765
"Off-peak" kilowatt hours: 10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 119,071 x ¢ 0.010/kwh	$	1,190
Subtotal	$	3,955

Fuel Adjustment Charges:

Total kilowatt hours = 264,574 x ¢ 0.04063	$	10,749
GRAND TOTAL for (demand, energy and fuel adjustment charges	$	15,214

TABLE 4

SHIFT FROM ON-PEAK TO PARTIAL PEAK WITH DEMAND LIMITING (WINTER)

Demand Charges:

"On-peak" per kilowatt of maximum demand

Total on peak 0 kW at $0.75	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,700 kW at $ 0.25	$	425
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,700 kW no charge	$	0
Subtotal	$	425

Energy Charge:

"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 0 x ¢ 0.019/kwh	$	0
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 213,670 x ¢0.014/kwh	$	2,991
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 146,901 x ¢ 0.010/kwh	$	1,469
Subtotal	$	4,460

Fuel Adjustment Charges:

Total kilowatt hours = 360,571 x ¢0.04063	$	14,650
GRAND TOTAL for (demand, energy and fuel adjustment charges	$	19,535

TABLE 4

UPGRADING HEAT TREAT FURNACES

Total Annual Gas Consumption	= 316,816 therms/year
Total Annual Cost	= $87,007.00
Average Cost of Gas	= $0.274 per therm

Assume approximately 75% of total gas input is attributed to heat treat operations; therefore, gas consumption for heat treat (316,816 x .75) equals 237,612 therms/year. Approximately 56% reduction in gas input is possible if the present furnaces were upgraded as follows:

- Install ceramic fiber linings*
- Install high efficiency burner system
- Install fuel/air ratio controls
- Install furnace pressure controls
- Install combustion air preheating

*3-1/2" ceramic liner has been installed on Furnace No. 1.

Potential Energy Savings (237,612 x 0.56)	= 133,062 therms/year
Cost Savings (133,062 therm x 0.274)	= $36,459.00

UPGRADING LADLE HEATERS

Approximate Ladle Heater Gas Consumption:

• Operation (A)		= 1,780,000 cu.ft./year
• Operation (B)		= 480,000 cu.ft./year
• Operation (C)		= 230,000 cu.ft./year
• Operation (D)		= 340,000 cu.ft./year
	TOTAL	2,830,000 cu.ft./year
	OR	28,300 therms/year

Approximately 40% reduction in gas input is possible if the present ladle heaters were upgraded as follows:

- Install ladle covers
- Install high efficiency burner system
- Install ceramic fiber lining

Potential Energy Savings (28,300 therm/year x 0.4)	= 11,320 therms/year
Potential Cost Savings (11,320 x 0.274)	= $3,102.00/year

NOTE: Energy costs are based on 1979 rates. Average gas costs have risen to $0.396/therm for the first six months of 1980.

PART F

ECONOMIC ANALYSIS

Payback period is calculated as follows:

.˙.Payback years for individual projects are listed in PART G based on order of magnitude costs as follows:

• Off-Peak Melting	$ -0-
• Upgrade Heat Treat Furnaces	80,000
• Upgrade Ladle Heaters	5,000
• Demand Control	10,000

The following conditions could lower the anticipated payback period considerably:

- Present day equipment costs used. However, the energy cost savings is based on 1979 calendar year average energy cost.
- No credit taken for government tax credit for installation of energy-saving devices.
- Calculation of return on investment utilizing life-cycle testing methods, which take into account depreciation, cost of money, and escalation of energy cost over the lifetime of the equipment, could possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

(ALTERNATE - 1)

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Demand controllers	---	$ 4,317	10,000	2.3
Upgrading Heat treat furnaces	13,300	36,460	80,000	2.2
Upgrading ladle heaters	2,830	3,100	5,000	1.6
TOTAL	16,130	$ 43,877	$ 95,000	2.16

TABLE 1

PART G

SUMMARY OF ENERGY REDUCTION

(ALTERNATE - 2)

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Off-peak melting	---	$ 61,064	---	---
Upgrading heat treat furnaces	13,300	36,460	80,000	2.2
Upgrading ladle heaters	2,830	3,100	5,000	1.6
Upgrading cupola furnaces				
TOTAL	16,130	$100,624	$ 85,000	0.84

TABLE 2

PART G

SUMMARY OF ENERGY REDUCTION

(ALTERNATE - 3)

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Load shifting and Demand controllers	---	$ 41,634	10,000	0.24
Upgrading heat treat furnaces	13,300	36,460	80,000	2.2
Upgrading ladle heaters	2,830	3,100	5,000	1.6
TOTAL	16,130	$ 81,194	$ 95,000	1.17

TABLE 3

FOUNDRY "C"

PROJECTED ENERGY-EFFICIENCY RECORD

(ALTERNATE 1)

MONTH OR YEAR RECORDED			1979/1980	
UNITS OF PRODUCTION			2,520	
FUEL COSTS				
• Electricity			$ 421,383 2/	
• Natural Gas			47,447	
• Propane				
• Oil				
• Coke			3,090	
• Other				
	TOTAL		$ 471,920	
ENERGY USED				
• KWH 6,499,920	x 3,412 Btu	=	22,177.7	Btu x 10^6
• Mcf Gas 15,551	x	1/	15,551.0	Btu x 10^6
• Gal. Propane	x 91,600 Btu	=		
• Gal. Oil	x 140,000 Btu	=		
• Coke - lb. 30,000	x 12,500 Btu	=	375	Btu x 10^6
•		=		
	TOTAL BTU		38,103.7	
ENERGY USED PER UNIT OF PRODUCTION				
(Million Btu) / (Units)	38,103.7 / 2,520	=	15.12	Btu x 10^6/ton
COST PER MILLION BTU				
(Energy Cost) / (Million Btu)	$471,920 / 38,103.7	=	12.38	Cost/Btu x 10^6
COST PER UNIT OF PRODUCTION				
(Total Cost) / (Units)	$471,920 / 2,520	=	$187.26	Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See gas bill for Btu content/cu.ft.

2/ Electricity cost based on 1980 "time of day" billing rates.

TABLE 4

FOUNDRY "C"

PROJECTED ENERGY-EFFICIENCY RECORD

(ALTERNATE 2)

MONTH OR YEAR RECORDED			1979/1980	
UNITS OF PRODUCTION			2,520	
			Net Good Tons/Yr.	
FUEL COSTS				
• Electricity			$ 364,636 2/	
• Natural Gas			47,447	
• Propane				
• Oil				
• Coke			3,090	
• Other				
	TOTAL		$ 415, 173	
ENERGY USED				
• KWH 6,499,920	x 3,412 Btu	=	22,177.7	Btu x 10^6
• Mcf Gas 15,551		1/	15,551.0	Btu x 10^6
• Gal. Propane	x 91,600 Btu	=		
• Gal. Oil	x 140,000 Btu	=		
• Coke - lb. 30,000	x 12,500 Btu	=	375	Btu x 10^6
•		=		
	TOTAL BTU		$ 38,103.7	Btu x 10^6
ENERGY USED PER UNIT OF PRODUCTION				
(Million Btu) / (Units)	38,103.7 / 2,520	=	15.12	Btu x 10^6/ton
COST PER MILLION BTU				
(Energy Cost) / (Million Btu)	$415,173 / 38,103.7	=	$10.89	Cost/Btu x 10^6
COST PER UNIT OF PRODUCTION				
(Total Cost) / (Units)	$415,173 / 2,520	=	$ 164.75	Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See gas bill for Btu content/cu.ft.

2/ Electricity cost based on 1980 "time of day" billing rates.

TABLE 5

FOUNDRY "C"

PROJECTED ENERGY-EFFICIENCY RECORD

(ALTERNATE 3)

MONTH OR YEAR RECORDED				1979/1980	
UNITS OF PRODUCTION				2,520 Net Good Tons/Yr.	
FUEL COSTS					
• Electricity			$	384,066 2/	
• Natural Gas				47,447	
• Propane					
• Oil					
• Coke				3,090	
• Other					
		TOTAL		$ 434,603	
ENERGY USED					
• KWH 6,499,920	x	3,412 Btu	=	22,177.7	Btu x 10^6
• Mcf Gas 15,551			1/	15,551.0	Btu x 10^6
• Gal. Propane	x	91,600 Btu	=		
• Gal. Oil	x	140,000 Btu	=		
• Coke - lb. 30,000	x	12,500 Btu	=	375	Btu x 10^6
•			=		
		TOTAL BTU		$38,103.7	Btu x 10^6
ENERGY USED PER UNIT OF PRODUCTION					
(Million Btu) / (Units)		38,103.7 / 2,502	=	15.12	Btu x 10^6
COST PER MILLION BTU					
(Energy Cost) / (Million Btu)		$434,603 / 38,103.7	=	$ 11.405	Cost/Btu x 10^6
COST PER UNIT OF PRODUCTION					
(Total Cost) / (Units)		$434,603 / 2,520	=	$172.46	Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See gas bill for Btu content/cu.ft.
2/ Electricity cost based on 1980 "time of day" billing rates.

TABLE 6

SECTION III

TABLE OF CONTENTS

FOUNDRY "D"

PART B

ENERGY USE TABLES

FOUNDRY "D"

ELECTRICAL POWER USAGE 3/

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL 1/	NET BILL 1/
JUNE 1979	475,200	1,184	84%	15,955	(20.94)	3,048	16,758	16,731
JULY 1979	457,600	1,184	84%	15,523	-	3,048	16,306	16,306
AUGUST 1979	457,600	1,184	84%	15,523	-	3,048	16,306	16,306 2/
SEPTEMBER 1979	481,600	1,176	84%	16,087	-	3,031	16,897	16,897
OCTOBER 1979	417,600	1,160	83%	15,456	-	2,997	16,242	16,242
NOVEMBER 1979	456,000	1,200	84%	15,558	-	3,082	16,341	16,341
DECEMBER 1979	435,200	1,168	83%	15,955	-	3,014	16,765	16,765
JANUARY 1980	318,400	-	84%	11,431	-	-	12,006	12,006
FEBRUARY 1980	404,800	-	85%	14,731	-	-	15,464	15,464
MARCH 1980	430,400	-	86%	18,439	(7.07)	-	19,358	19,351
APRIL 1980	451,200	-	87%	19,940	(15.16)	-	20,933	20,918
MAY 1980	452,800	-	87%	23,314	(17.22)	-	24,476	24,459
TOTALS	5,238,400							207,786

1/ Includes Power Factor Adjustment and City Taxes
2/ August 1979 Bill Missing (used same as July)
3/ A-22 Rate Schedule

Average Cost = $\frac{207,786}{5,238,400}$ = $0.04/KWH

TABLE 1

FOUNDRY "D"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST	
JUNE 1979	31,224	3,122.4	8,286.00	
JULY 1979	37,075	3,707.5	10,713.00	
AUGUST 1979	31,224	3,122.4	8,286.00	1/
SEPTEMBER 1979	32,254	3,225.4	9,510.00	
OCTOBER 1979	27,391	2,739.1	7,692.00	
NOVEMBER 1979	25,228	2,522.8	7,948.00	
DECEMBER 1979	25,094	2,509.4	8,530.00	
JANUARY 1980	17,225	1,722.5	6,001.00	
FEBRUARY 1980	24,981	2,498.1	9,124.00	
MARCH 1980	26,453	2,645.3	10,434.00	
APRIL 1980	30,935	3,093.5	12,555.00	
MAY 1980	26,476	2,647.6	11,086.00	
TOTALS	335,560	33,556.0	110,165.00	

1/ August Gas Bill Missing (June bill used)

HEAT CONTENT OF GAS = BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{110,165}{335,560}$ = \$ 0.33 PER THERM

TABLE 2

FOUNDRY "D"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	AMPS
WAX							
WAX MACHINES (6)							42
LEYDEN MACHINES (3)							90
INJECTION MACHINES (4)							29
WAX TANKS							24
WAX ASSEMBLY							35
DRYING ROOM							
DRYER CABINETS					1-1/2		
WAX EXTR.					15		
DIPPING							45
A/C SYSTEMS					140		
COMP. (2)					190		
STRAIGHTENING					35		
HEAT TREAT					65		
2 YGLO							60
X-RAY					10		
DIE SHOP					17		
MACHINE SHOP					38		
FINISHING					48		
MELT					63		

TABLE 3

TABLE 3 (CONTINUED)

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	AMPS
CUT-OFF					209		
FURNACE #1	AJAX (INDUCT.)					150	
FURNACE #2	AJAX (INDUCT.)					150	
FURNACE #3	INDUCTO THERM					325	

TABLE 3

FOUNDRY "D"

DESCRIPTION AND FLOW RATES OF GAS FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
BURN-OUT OVEN #1	N/A	8	Premix	24	21	-	1000
BURN-OUT OVEN #2	N/A	8	Premix	24	21	-	1000
BURN-OUT OVEN #3	N/A	2	Premix	24	21	-	400
AFTER BURN	N/A	1	Premix	3	21	-	350*
HT FURN	-	-	-	-	-	-	560**
SALT BATH # 1	-	2	Premix	5	21	-	300
SALT BATH #2	-	2	Premix	5	21	-	300
LADLE HEATERS	N/A	1	Open Touch	10	21	-	250
STEAM BOILER	N/A	1	Premix	10	21	-	469
TOTALS							4629

* 100 CFM when idling

** Not in general use

TABLE 4

FOUNDRY "D"

1979 ENERGY - EFFICIENCY RECORD

MONTH OR YEAR RECORDED	JUNE 1979 - MAY 1980
UNITS OF PRODUCTION	500/YEAR NET GOOD TON
FUEL COSTS	
• Electricity	$ 207,786.00
• Natural Gas	110,165.00
• Propane	
• Oil	
• Coke	
• Other	
TOTAL	317,951.00

ENERGY USED

• KWH	5,238,400	x	3,412 Btu	=	17,873.4	Btu x 10^6
• Mcf Gas	33,556	x		1/	33,556	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	NONE	
• Gal. Oil		x	140,000 Btu	=	NONE	
• Coke - lb.		x	12,500 Btu	=	NONE	
•				=		
			TOTAL BTU		51,429.4	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{51{,}429.4}{500 \text{ TONS}}$ = 102.85 Btu x 10^6/TON

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{317{,}951}{51{,}429.4}$ = 6.18 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{317{,}951}{500}$ = 635.9 Cost/Unit

OR 32¢ per lb.

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "D"

ENERGY-EFFICIENCY RECORD[2/] [3/]

MONTH OR YEAR RECORDED	1980 PROJECTED (ELECTRICITY ONLY)
UNITS OF PRODUCTION	500 NET GOOD TONS PER YEAR
FUEL COSTS	
• Electricity	$ 314,304.00
• Natural Gas	110,165.00
• Propane	NONE
• Oil	NONE
• Coke	NONE
• Other	NONE
TOTAL	$ 424,469.00

ENERGY USED

• KWH	5,238,400	x	3,412 Btu	=	17,873.4	Btu x 10^6
• Mcf Gas	33,556	x		1/	33,556	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	--	
• Gal. Oil		x	140,000 Btu	=	--	
• Coke - lb.		x	12,500 Btu	=	--	
•				=	--	
			TOTAL BTU		51,429.4	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{51,429}{500} = 102.85 \text{ Btu} \times 10^6\text{/Ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{424,469}{51,429.4} = \$ \; 8.25 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{424,469}{500} = \$ \; 848.93 \text{ Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with "Time of Day" billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of "Off-Peak" melting and demand control.

3/ All other energy costs are 1979 rates.

TABLE 6

PART C

PRODUCTION STATISTICS

ANNUAL PRODUCTION

PART "C"

FOUNDRY "D"

CASTING METAL Alloy Steel

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	N/A	N/A	N/A	N/A
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
TOTALS	1,000	500.0		$15,000,000

AVERAGE MELT TONS/DAY = N/A

REPORTED % SCRAP N/A

REPORTED % MELT LOSS N/A

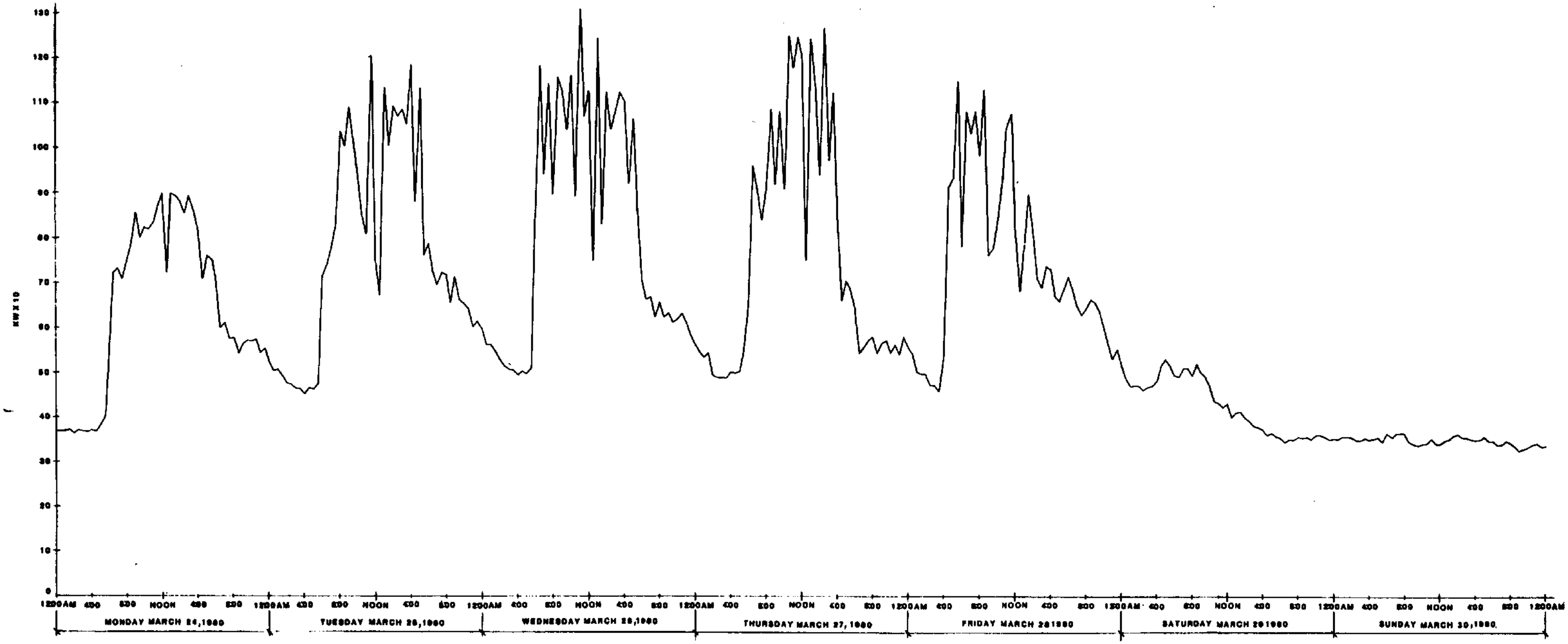
AVERAGE FOUNDRY YIELD % 50.0

AVERAGE SALES VALUE/LB. N/A

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE (WINTER)
INDUCTION FURNACE & GENERAL PLANT SERVICE

FOUNDRY D

FIGURE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

FURNACE #1

Furnace make N/A

Model N/A

Capacity 600#

Transformer KVA 325

Primary Voltage ______

Secondary Voltage ______

Output N/A tons/year

N/A tons/day

Alloy HIGH CARBON STEEL, STAINLESS AND HI ALLOY STEEL

Melt cycle 45 minutes

Tap quantity N/A lbs.

Charge quantity N/A lbs.

Tap temperature N/A °F

Holding temperature N/A °F

Slag cycle N/A minutes

Fume collection N/A CFM

Water cooling N/A GPM, Temp N/A In °F N/A Out °F

Type of refractory N/A

Energy consumption N/A KWH/YEAR

Energy cost 0.04 ¢/KWH

TABLE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

FURNACE #2

Furnace make	N/A	Transformer KVA	150
Model	N/A	Primary Voltage	
Capacity	200	Secondary Voltage	

Output N/A tons/year

N/A tons/day

Alloy SAME AS FURNACE #1

Melt cycle 25 minutes

Tap quantity N/A lbs.

Charge quantity N/A lbs.

Tap temperature N/A °F

Holding temperature N/A °F

Slag cycle N/A minutes

Fume collection N/A CFM

Water cooling N/A GPM, Temp N/A In °F N/A Out °F

Type of refractory N/A

Energy consumption N/A KWH/YEAR

Energy cost 0.04 ¢/KWH

TABLE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

FURNACE #3

Furnace make	N/A	Transformer KVA	150
Model	N/A	Primary Voltage	
Capacity	30#	Secondary Voltage	

Output ______ N/A ______ tons/year

______ N/A ______ tons/day

Alloy ______ SAME AS FURNACE #1 ______

Melt cycle ______ 7 ______ minutes

Tap quantity ______ N/A ______ lbs.

Charge quantity ______ N/A ______ lbs.

Tap temperature ______ N/A ______ °F

Holding temperature ______ N/A ______ °F

Slag cycle ______ N/A ______ minutes

Fume collection ______ N/A ______ CFM

Water cooling __N/A__ GPM, Temp __N/A__ In °F __N/A__ Out °F

Type of refractory ______ N/A ______

Energy consumption ______ N/A ______ KWH/YEAR

Energy cost ______ 0.04 ______ ¢/KWH

TABLE 1

OPERATIONAL DATA FACT SHEET

BURN-OUT FURNACES (TWO SUCH)

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	NO. OF BURNERS 8
SIZE 7' x 7' x 12'	TYPE Pre Mix SIZE 1,000,000 BTU/HR
CAPACITY N/A LBS.	FUEL Natural Gas
TYPE OF LINING 9" Fiber Lining	AFTER BURNER MAKE N/A
	MODEL N/A
EXHAUST BLOWER MAKE N/A	TYPE Pre Mix SIZE 350,000 BTU/HR
MODEL N/A	OPERATING HOURS
SIZE ____ CFM. PRESS ____ "WG	MAIN BURNER 120 Hrs/Wk
VOLT ____ HP ____	AFTER BURNER 50 Hrs/Wk
TYPE OF FURNACE CYCLE N/A	
FURNACE CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
CYCLES PER WEEK N/A	FURNACE PRESSURE N/A
TEMPERATURE 2,100°F	CO_2 IN FLUE GAS N/A
LOAD DENSITY — N/A	FUEL CONSUMPTION N/A Therms/Day

REMARKS:

TABLE 2

OPERATIONAL DATA FACT SHEET

BURN-OUT FURNACES (ONE SUCH)

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	NO. OF BURNERS 2
SIZE 7' x 7' x 12'	TYPE Pre Mix SIZE 400,000 BTU/HR
CAPACITY N/A LBS.	FUEL Natural Gas
TYPE OF LINING 9" Fiber Lining	AFTER BURNER MAKE N/A
	MODEL N/A
EXHAUST BLOWER MAKE N/A	TYPE Pre Mix SIZE 350,000 BTU/HR
MODEL N/A	OPERATING HOURS
SIZE ____ CFM. PRESS ____ "WG	MAIN BURNER 120 Hrs/Wk
VOLT ____ HP ____	AFTER BURNER 50 Hrs/Wk
TYPE OF FURNACE CYCLE N/A	
FURNACE CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
CYCLES PER WEEK N/A	FURNACE PRESSURE N/A
TEMPERATURE 2,100°F	CO_2 IN FLUE GAS N/A
LOAD DENSITY - N/A	FUEL CONSUMPTION N/A Therms/Day

REMARKS:

TABLE 2

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

LADLE CAP TONS N/A HEAT CYCLES/DAY N/A

LADLE AREA INSIDE N/A SQ FT. LINING THICKNESS N/A

COVERED No TYPE OF LINING Conventional F.B.

INSIDE TEMP N/A ^{o}F OUTER SHELL TEMP N/A ^{o}F

AMBIENT TEMP Varies ^{o}F

GAS USAGE/HR 250 * CU FT. CO_2 READING N/A

COMBUSTION AIR N/A CFM PRESSURE N/A WG

PREHEAT CYCLE TIME N/A HRS FLUE TEMP N/A ^{o}F

REFRACTORY K VALUE N/A RS VALUE N/A

BLOWER HP None RECUPERATOR EFFCY None

FUEL COST/THERM $ 0.33 ANNUAL USE 600 * BTU x 10^6

NUMBER OF UNITS IN USE One

* Assumed

TABLE 3

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES (ELECTRIC)

FURNACE MAKE ____________ MODEL Vacuum

SIZE N/A INSIDE 7' Dia. x 6' Long OUTSIDE

CAPACITY 3,000 LBS. TYPE N/A

WALL THICKNESS N/A TEMP. RANGE N/A °F

HEATING ELEMENT 440 VOLTS 95 AMPS 150 kW

HEAT TREAT CYCLE - HEAT-UP N/A HRS

SOAK N/A HRS

COOL DOWN N/A HRS

CYCLES PER WEEK N/A

ELECTRICAL CONSUMPTION N/A KWH/CYCLE

REMARKS:

TABLE 4

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES (ELECTRIC)

FURNACE MAKE Globar MODEL N/A

SIZE N/A INSIDE 5'-6'x 5' high OUTSIDE

CAPACITY N/A LBS. TYPE N/A

WALL THICKNESS N/A TEMP. RANGE 1400 - 2100 °F

HEATING ELEMENT 250 VOLTS 200 AMPS ______ kW

HEAT TREAT CYCLE - HEAT-UP N/A HRS

SOAK N/A HRS

COOL DOWN N/A HRS

CYCLES PER WEEK N/A

ELECTRICAL CONSUMPTION N/A KWH/CYCLE

REMARKS:

TABLE 4

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES (ELECTRIC)

FURNACE MAKE N/A MODEL Pit Type

SIZE N/A INSIDE 5' dia. x 40" hi. OUTSIDE

CAPACITY N/A LBS. TYPE N/A

WALL THICKNESS N/A TEMP. RANGE 500 - 1400 °F

HEATING ELEMENT 110 VOLTS 10 AMPS ______ kW

HEAT TREAT CYCLE - HEAT-UP N/A HRS

SOAK N/A HRS

COOL DOWN N/A HRS

CYCLES PER WEEK N/A

ELECTRICAL CONSUMPTION N/A KWH/CYCLE

REMARKS:

TABLE 4

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15- to 30-minute periods.

ELECTRICAL ENERGY COST SAVINGS

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Percentage of total energy usage by electrical load:

$$= \frac{\text{Electrical Energy}}{\text{Total Energy}} = \frac{17{,}873.4 \times 10^6}{51{,}429.4 \times 10^6} \times 100 = 34.75\%$$

1/ Melting energy usage at 30% = 5,238,400 x 30

= 1,571,520 KWH

Based on a sample billing period of one month each at summer and winter rate schedules, the cost reduction potential is:

1. Demand Control

	Summer	Winter	Total
Normal melting cost 2/	\$ 8,629	\$ 7,601	\$16,230
Demand limited cost 3/	7,955	7,407	15,362
Reduction			\$ 868

Percent savings $= \frac{\text{Reduction in cost}}{\text{Normal cost of melting}} = \underline{5.3\%}$

Therefore, annual savings:

= Melt. KWH x Avg. Cost/KWH* x Percent Savings

= 1,571,520 x .06 x .053 = \$4,997/year

For graphic illustration of methodology used in calculating electrical savings see Figures 1 and 2.

2. Off-Peak Melting 4/

	Summer	Winter	Total
Normal melting cost	\$ 8,629	\$ 7,601	\$16,230
Off-Peak melting cost	6,748	6,845	13,593
Total			\$ 2,637

*Note: 1980 energy costs used.

1/ Work sheet - Table 5
2/ Work sheet - Table 1
3/ Work sheet - Table 2
4/ Work sheet - Table 3

$$\text{Percent savings} = \frac{2,637}{16,230} = 16.2\%$$

Therefore, annual savings:

= Melt. KWH x Avg. Cost/KWH* x Percent Savings

= 1,571,520 x .06 x .162 = $15,275/year

For graphic illustration of methodology used in the calculation of electrical savings see Figure 3 and 4.

3. Demand Limiting and Load Shifting

	Summer	Winter	Total
Normal melting cost	$ 8,629	$ 7,601	$16,230
Revised melting cost 5/	7,466	7,199	14,665
Total			1,565

$$\text{Percent savings} = \frac{1,565}{16,230} = 9.6\%$$

Therefore, annual savings:

= Melt. KWH x Avg. Cost/KWH* x Percent Savings

= 1,571,520 x .06 x .096 = $9,052/year

For graphic illustration of methodology used in these calculations of electrical savings see Figures 5 and 6.

*Note: 1980 energy costs used.

5/ Work sheet - Table 4

FOUNDRY "D"

NORMAL MELTING-SUMMER

Demand Charges:

"On-peak" per kilowatt of maximum demand	
Total on peak 400 kW at $ 2.50	$ 1,000
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 408 kW at $ 0.30	$ 122
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 368 kW no charge	$ 0
Subtotal	$ 1,122

Energy Charge:

"On-peak" per kilowatt hour:	
12:30 pm to 6:30 pm hrs/day	
Total kilowatt hours 29,400 x ¢ 0.022/kwh	$ 647
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm	
and 6:30 pm to 10:30 pm .8 hrs/day	
Total kilowatt hours 45,110 x ¢ 0.019/kwh	$ 857
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 58,750 x ¢ 0.010/kwh	$ 588
Subtotal	$ 2,092

Fuel Adjustment Charges:

Total kilowatt hours = 133,263 x ¢ 0.04063	$ 5,415
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$ 8,629

TABLE 1

FOUNDRY "D"

NORMAL MELTING-WINTER

Demand Charges:

"On-peak" per kilowatt of maximum demand		
Total on peak 340 kW at $ 0.75	$	255
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 394 kW at $ 0.25	$	99
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 355 kW no charge	$	0
Subtotal	$	354

Energy Charge:

"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 17,571 x ¢ 0.019/kwh	$	334
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 60,847 x ¢ 0.014/kwh	$	852
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 56,783 x ¢ 0.010	$	568
Subtotal	$	1,754

Fuel Adjustment Charges:

Total kilowatt hours = 135,200 x ¢ 0.04063	$	5,493
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	7,601

TABLE 1

FOUNDRY "D"

DEMAND LIMITING (SUMMER)

Demand Charges:

"On-peak" per kilowatt of maximum demand

Total on peak 160 kW at $ 2.50	$	400
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 160 kW at $ 0.30	$	48
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 160 kW no charge	$	0
Subtotal	$	448

Energy Charge:

"On-peak" per kilowatt hour:

12:30 pm to 6:30 pm hrs/day

Total kilowatt hours 29,400 x ¢ 0.022/kwh	$	647
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm 8 hrs/day		
Total kilowatt hours 45,110 x ¢ 0.019/kwh	$	857
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 58,750 x ¢ 0.010/kwh	$	588
Subtotal	$	2,092

Fuel Adjustment Charges:

Total kilowatt hours = 133,263 x ¢ 0.04063	$	5,415
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	7,955

TABLE 2

FOUNDRY "D"

DEMAND LIMITING (WINTER)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 160 kW at $ 0.75	$	120
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 160 kW at $ 0.25	$	40
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 160 kW no charge	$	0
Subtotal	$	160
Energy Charge:		
"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 17,571 x ¢ 0.019/kwh	$	334
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 60,847 x ¢ 0.014/kwh	$	852
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 56,783 x ¢ 0.010	$	568
Subtotal	$	1,754
Fuel Adjustment Charges:		
Total kilowatt hours = 135,200 x ¢ 0.04063	$	5,493
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	7,407

TABLE 2

FOUNDRY "D"

OFF-PEAK MELTING (SUMMER)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 0 kW at $ 2.50	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 0 kW at $ 0.30	$	0
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 408 kW no charge	$	0
Subtotal	$	0
Energy Charge:		
"On-peak" per kilowatt hour:		
12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 0 x ¢ 0.022/kwh	$	0
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm 8 hrs/day		
Total kilowatt hours 0 x ¢ 0.019/kwh	$	0
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 133,263 x ¢ 0.010/kwh	$	1,333
Subtotal	$	1,333
Fuel Adjustment Charges:		
Total kilowatt hours = 133,263 x ¢ 0.04063	$	5,415
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	6,748

TABLE 3

SHEET 1 of 2

FOUNDRY "D"

OFF-PEAK MELTING (WINTER)

Demand Charges:

"On-peak" per kilowatt of maximum demand		
Total on peak 0 kW at $ 0.75	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 0 kW at $ 0.25	$	0
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 394 kW no charge	$	0
Subtotal	$	0

Energy Charge:

"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 0 x ¢ 0.019/kwh	$	0
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 0 x ¢0.014/kwh	$	0
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 135,200 x ¢0.010/kwh	$	1,352
Subtotal	$	1,352

Fuel Adjustment Charges:

Total kilowatt hours = 135,200 x ¢0.04063	$	5,493
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	6,845

TABLE 3

FOUNDRY "D"

ON-PEAK MELTING SHIFTED TO PARTIAL AND OFF-PEAK (SUMMER) WITH DEMAND LIMITING

Demand Charges:

"On-peak" per kilowatt of maximum demand	
Total on peak 0 kW at $ 2.50	$ 0
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 160 kW at $ 0.30	$ 48
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 160 kW no charge	$ 0
Subtotal	$ 48

Energy Charge:

"On-peak" per kilowatt hour:	
12:30 pm to 6:30 pm hrs/day	
Total kilowatt hours 0 x ¢ 0.022/kwh	$ 0
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm	
and 6:30 pm to 10:30 pm .8 hrs/day	
Total kilowatt hours 74,510 x ¢ 0.019/kwh	$ 1,416
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 58,750 x ¢ 0.010/kwh	$ 588
Subtotal	$ 2,004

Fuel Adjustment Charges:

Total kilowatt hours = 133,263 x ¢ 0.04063	$ 5,414
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$ 7,466

TABLE 4

SHEET 1 of 2

FOUNDRY "D"

ON-PEAK MELTING SHIFTED TO PARITAL AND OFF-PEAK (WINTER) WITH DEMAND LIMITING

Demand Charges:

"On-peak" per kilowatt of maximum demand

Total on peak 0 kW at $0.75	$ 0
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 160 kW at $ 0.25	$ 40
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 160 kW no charge	$ 0
Subtotal	$ 40

Energy Charge:

"On-peak" per kilowatt hour:	
4:30 pm to 8:30 pm 4 hrs/day	
Total kilowatt hours 0 x ¢ 0.019/kwh	$ 0
"Partial peak" kilowatt hours:	
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day	
Total kilowatt hours 78,418 x ¢0.014/kwh	$ 1,098
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 56,783 x ¢ 0.010/kwh	$ 568
Subtotal	$ 1,666

Fuel Adjustment Charges:

Total kilowatt hours = 135,200 x ¢0.04063	$ 5,493
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$ 7,199

TABLE 4

SHEET 2 of 2

TOTAL MELTING ENERGY (Use actual metered consumption if available or estimate as follows:)

$$\frac{\text{Annual tons shipped}}{\text{Overall Foundry yield \%}} = \text{Total tons melted per year}$$

Total tons melted X average kWh/ton = Total energy

Example:

$$\frac{\text{Annual tons shipped}}{\text{Foundry yield \%}} = \frac{500}{.5} = 1{,}000$$

(a) Therefore, Tons melted/year X kWh/ton* = 1,000 x 1,572

= 1,572,000 KWH

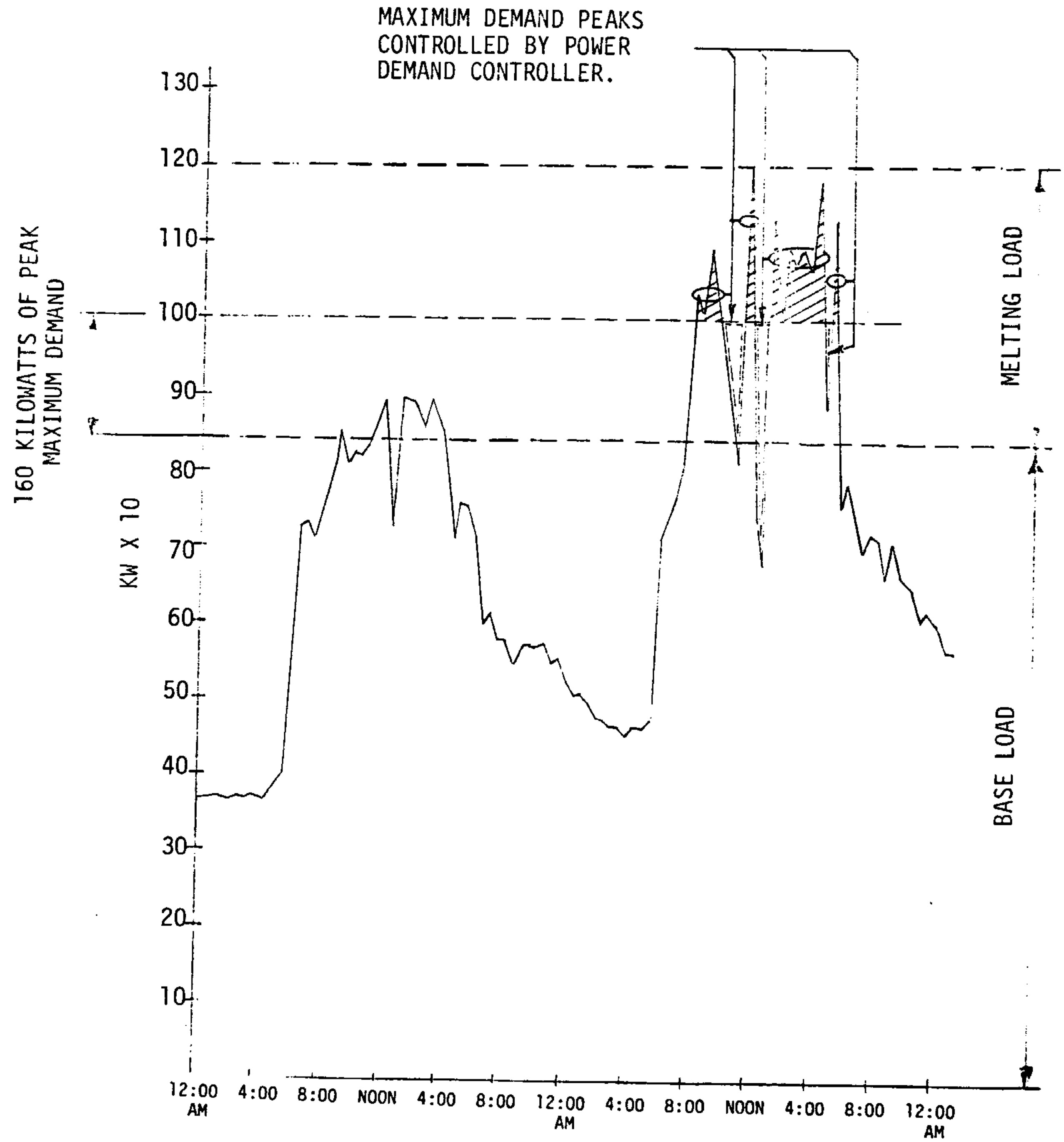
Percent melting energy of total electrical usage

$$= \frac{\text{(a) KWH}}{\text{Total Electric Energy KWH}} = \%$$

$$= \frac{1{,}572{,}000}{5{,}238{,}400} = 30\%$$

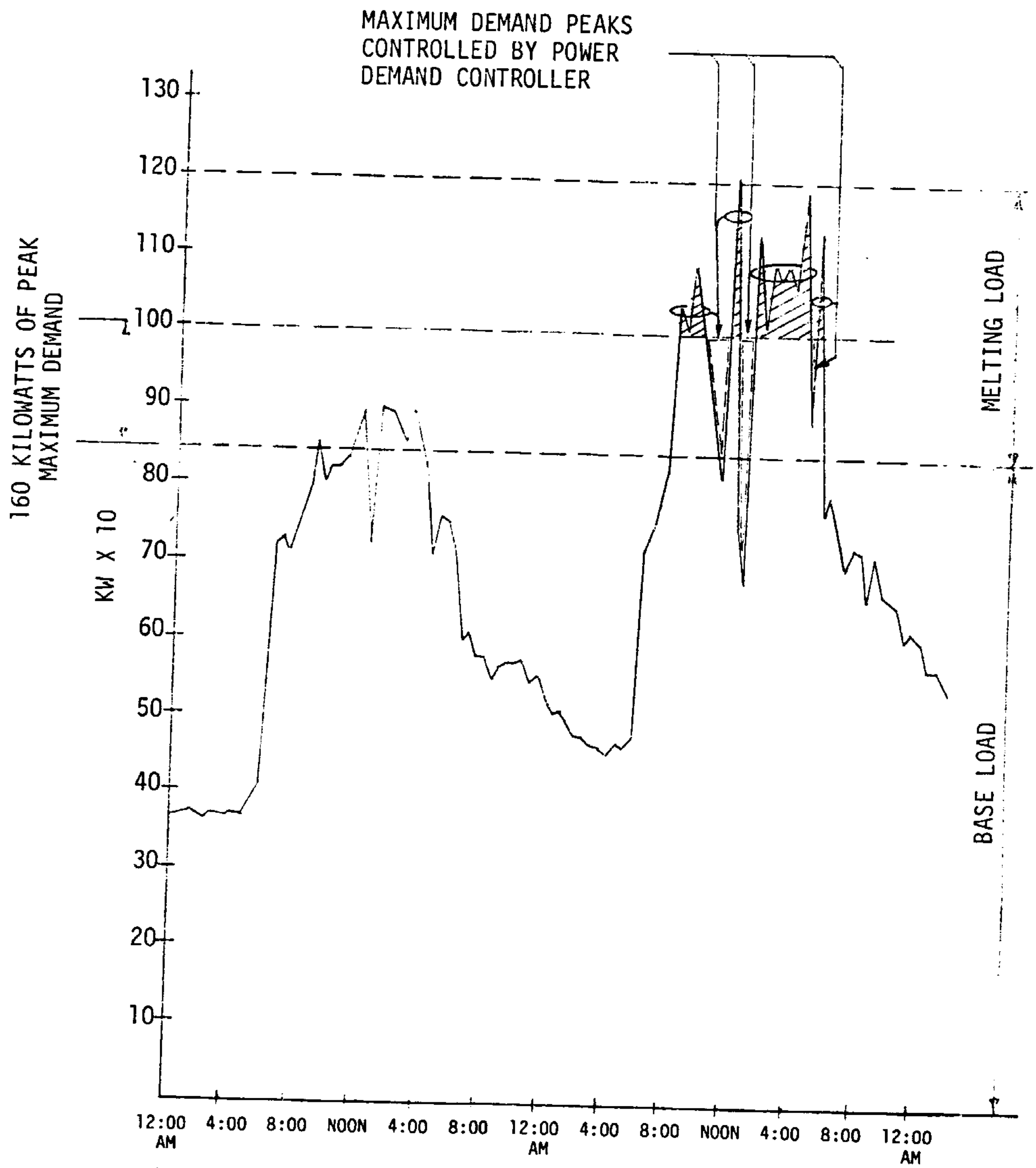
*Note: kWh/ton determined from actual melt cycle or use industry average for type of furnace and metal melted.

TABLE 5



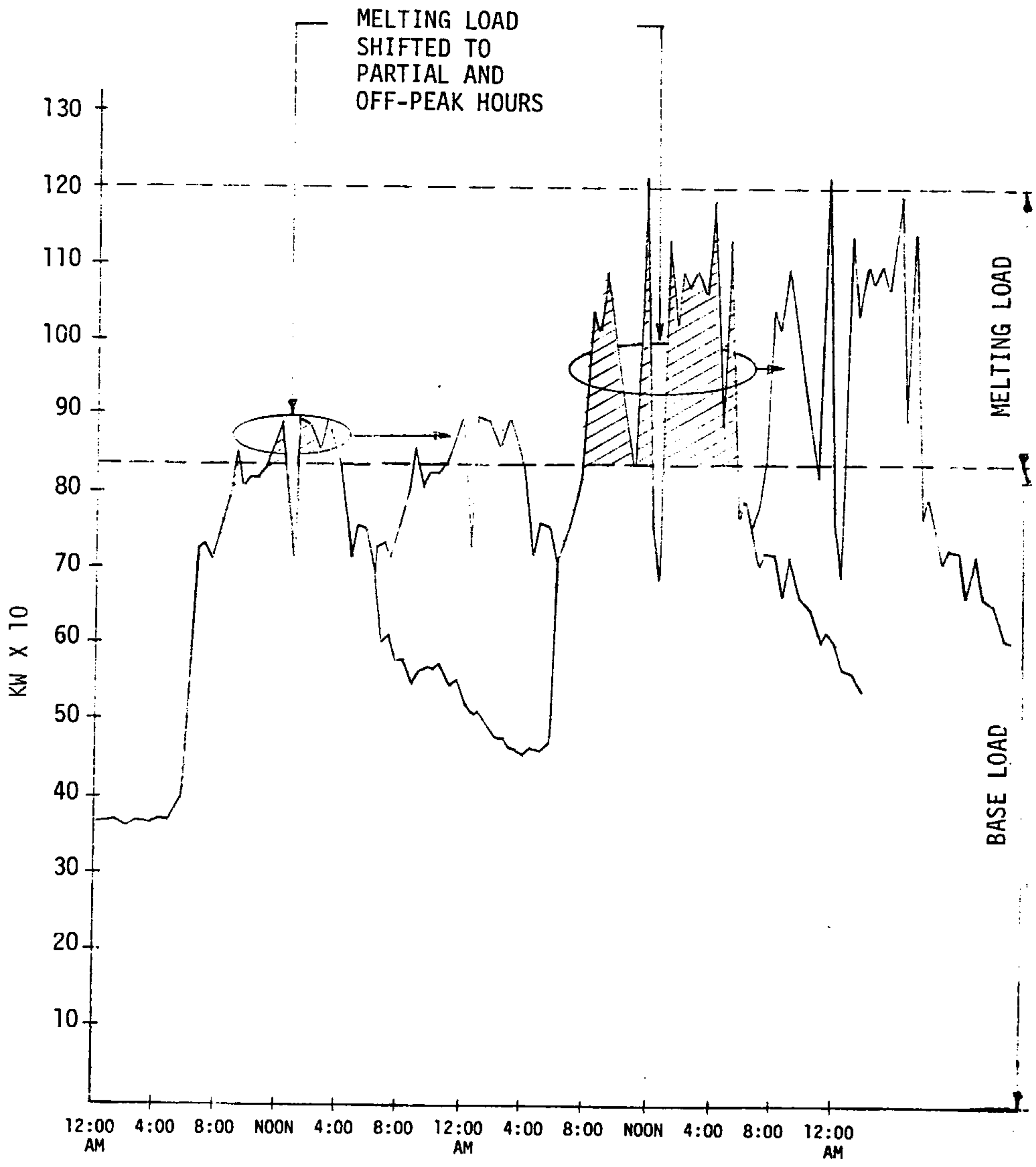
SUMMER - "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE

FIGURE 1



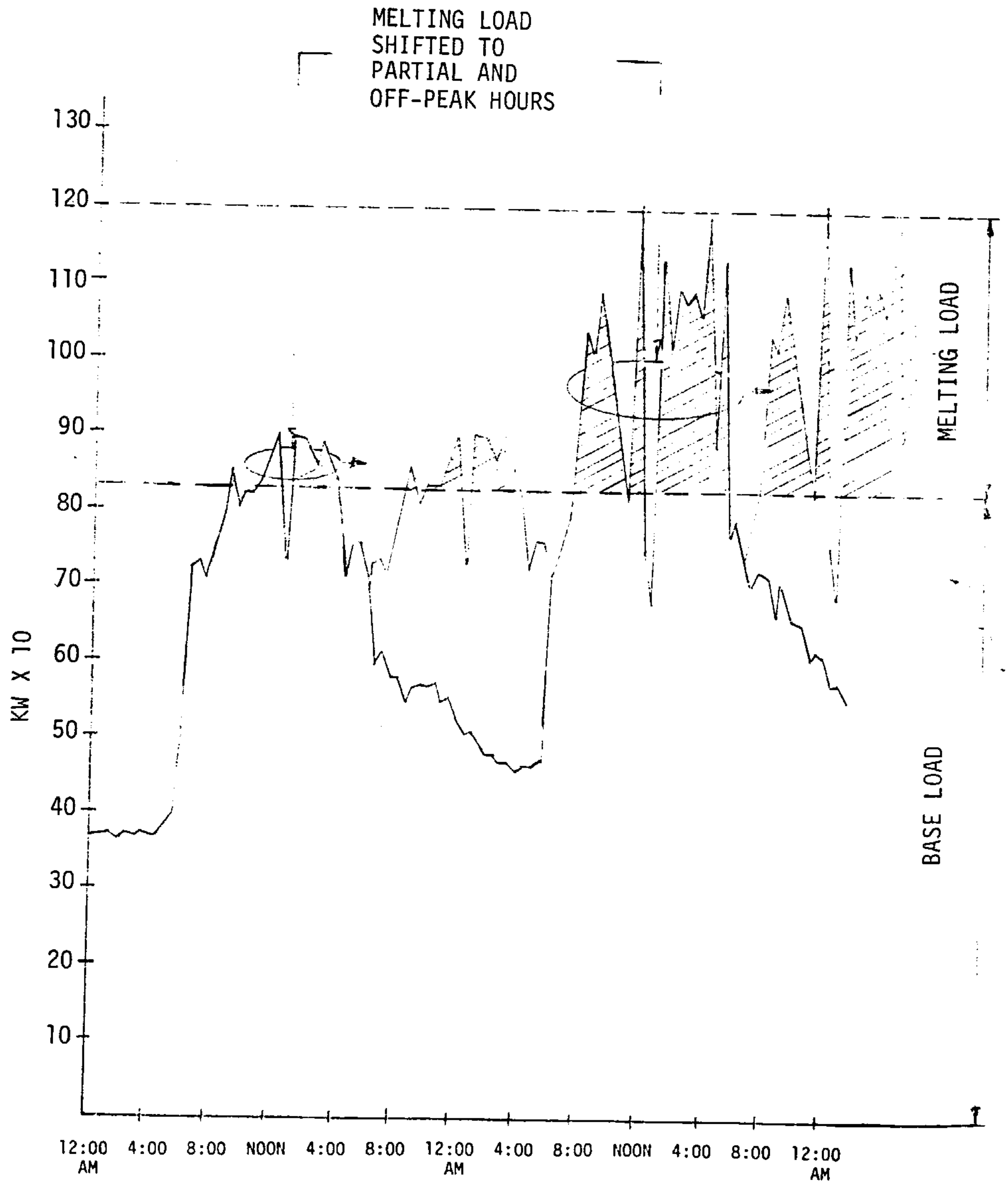
WINTER - "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE

FIGURE 2



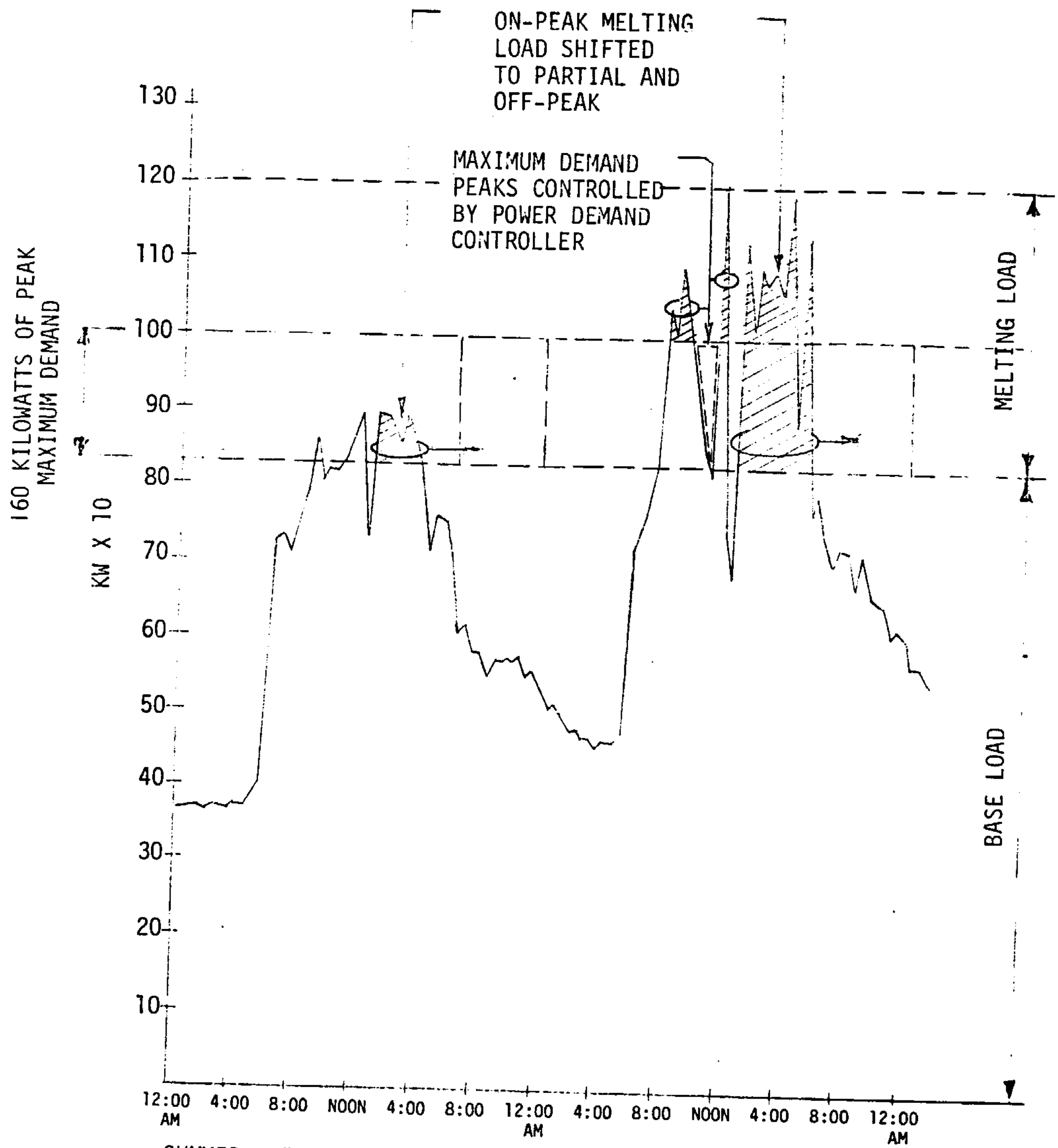
SUMMER - "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE

FIGURE 3



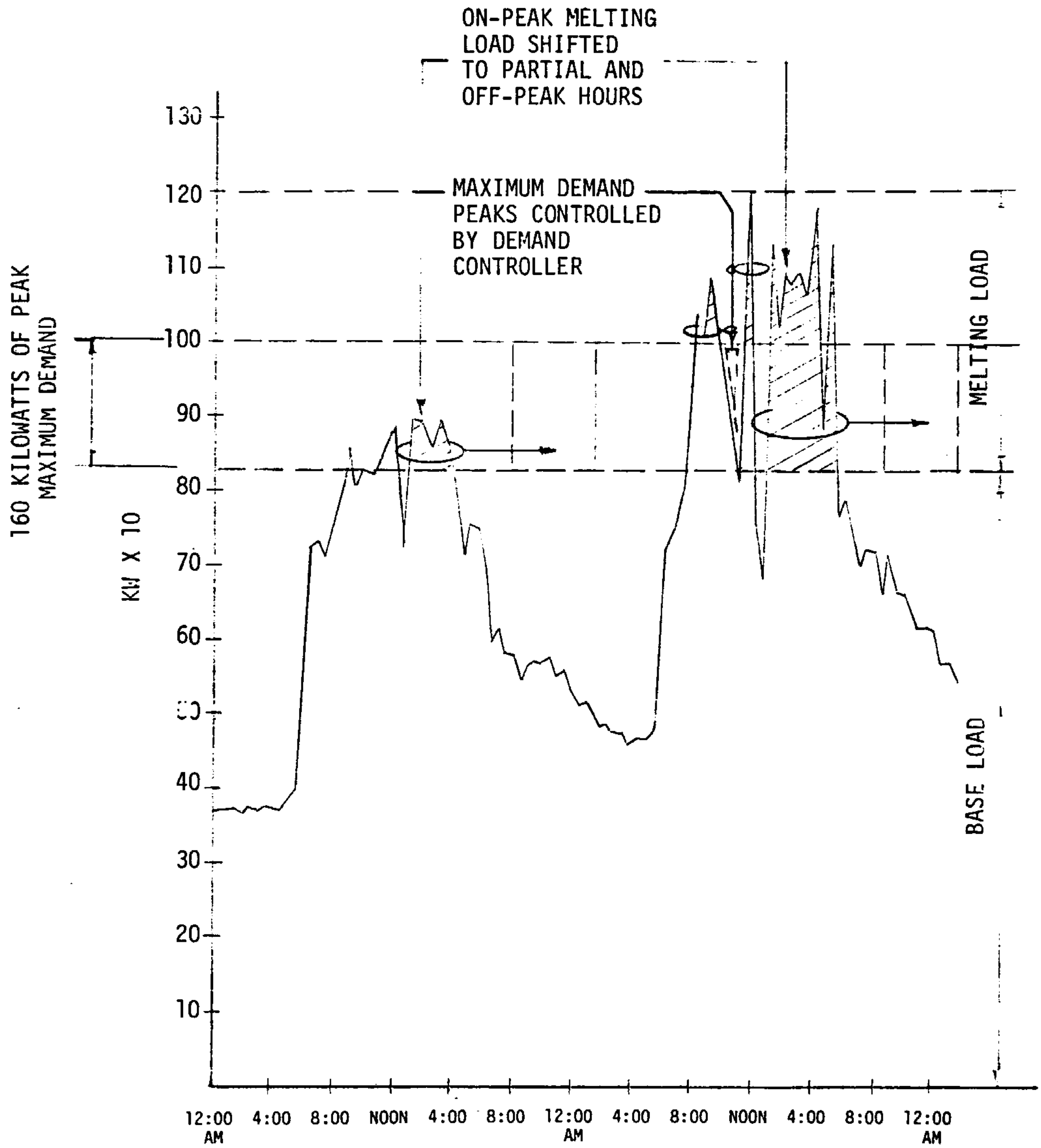
WINTER - "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE

FIGURE 4



SUMMER - "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE

FIGURE 5



WINTER - "TIME OF DAY" BILLING KILOWATT DEMAND PROFILE

FIGURE 6

Upgrading Heat Treat Furnace

Improved efficiency by upgrading of lining materials can be realized in the order of percent energy loss reduction as follows:

Heat loss through furnace walls (typical lining)
= 289 Btu/Hr/sq. ft.
Improved lining material = 87 Btu/Hr/sq. ft.
201 Btu/Hr/sq. ft.

Percent improvement = 70%

Energy reduction based on furnace wall areas as follows:

Vacuum - 125 sq. ft.
Globar - 137 sq. ft.
Pit type - 53 sq. ft.
315 sq. ft. X 201 Btu/Hr/sq. ft.
= 63,300 Btu/hr

Based on 6 Hours/day utilization = 380,000 Btu

	Heat input	
Vacuum furnace	150	KW
Globar furnace	50	KW
Pit type furnace	1.1	KW
Total	201.1	

Operating basis 6 hrs/day = 1,206.6 KWH/day
= 4.12×10^6 Btu/day

$$\text{Energy cost reduction} = \frac{380{,}000}{3{,}412} = 111 \text{ KWH/day}$$

$$@\ \$0.04/\text{KWH} = \$4.44/\text{day}$$

$$\text{Annual cost reduction} = \underline{\$1{,}065}$$

$$\text{Percent energy savings} = \frac{111}{1{,}206.6} = 9.2\%$$

$$\text{Annual Energy reduction} = 111 \times 240$$

$$= 26{,}640 \text{ KWH}$$

$$@\ 3{,}412 \text{ Btu/KWH} = \underline{90.9 \times 10^6 \text{ Btu}}$$

UPGRADING LADLE HEATERS

Annual gas usage for ladle heating (assumes) = 600 BTU x 10^6
or 6,000 Therms/yr

Energy savings can be realized by upgrading ladle heaters in the following areas:

- Install ladle covers
- Install ceramic fiber insulation
- Install high efficiency burner system

Approximately 40% increase in ladle heating efficiency is possible, therefore--

Potential energy savings (6,000 x 0.4) = 2,400 Therms/yr

Potential cost savings (2,400 therms x 0.33) = $ 792.00/yr

UPGRADING BURN-OUT FURNACES

From Table IV, Part B of this section. Approximately 4629 cu. ft. of gas is consumed per hour; this figure includes 560 cu. ft. of gas consumption for the gas fired heat treat furnace which is not operational -- therefore, probable consumption is:

$$\frac{2750 \text{ CFH}}{4069 \text{ CFH}} \times 100 = 67.5\%$$

Total Annual Gas Usage	= 335,560 Therms/yr
Total Annual Gas Cost	= $110,165.00
Average Gas Cost	= $0.33/Therm

Substantial energy savings can be realized by upgrading the burn-out furnaces in the following areas:

- Install ceramic fiber insulation liners
- install high efficiency burner system on primary and after burn operations
- Install recuperator for combustion air pre-heating

Potential energy savings (based on 56% increase in efficiency) is

(0.675 x 335,560 x .56)	= 126,841 Therm/yr
Potential cost savings	
(126,841 x .33)	=$41,857.00 /yr

PART F

ECONOMIC ANALYSIS

PART F

ECONOMIC ANALYSIS

Payback period is calculated as follows:

$$\frac{\text{Total Capital Investment}}{\text{Gross Energy Cost Reduction/year}} = \text{years}$$

Payback years for individual projects are listed in Part G, based on order of magnitude costs as follows:

• Off-peak melting	-0-
• Load shifting and demand limiting	$ 10,000
• Upgrade heat treat furnaces	10,000
• Upgrade ladle heaters	3,000
• Demand control	10,000
• Upgrade burn-out furnaces	80,000

The following conditions could lower the anticipated payback period considerably:

- Present day equipment costs used (while the energy savings cost is based on 1979 calendar year average energy costs, with the exception of electrical costs which are based on 1980 rates).

- No credit taken for government tax break for installation of energy saving devices.

- Calculation of return on investment utilizing life-cycle costing methods, which take into account depreciation, cost of money and escalation of energy cost over the lifetime of the equipment, will possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

ALTERNATE 1

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD YEAR
Demand controllers	--	$ 4,997	$ 10,000	2.0
Upgrading heat treat furnaces (Electric)	90.9	1,065	10,000	9.4
Upgrading ladle heaters	240	790	3,000	3.8
Upgrading burn-out furnaces	12,684.1	41,860	80,000	1.9
TOTAL	13,015.0	$48,712	$ 103,000	2.11

TABLE 1

PART G

SUMMARY OF ENERGY REDUCTION

ALTERNATE 2

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD YEAR
Load shifting and demand controller	--	$ 9,052	$ 10,000	1.1
Upgrading heat treat furnaces (Electric)	90.9	1,065	10,000	9.4
Upgrading ladle heaters	240.0	790	3,000	3.8
Upgrading burn-out furnaces	12,684.1	41,860	80,000	1.9
TOTAL	13,015.0	$52,767	$ 103,000	1.95

TABLE 2

PART G

SUMMARY OF ENERGY REDUCTION

ALTERNATE 3

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD YEAR
Off-peak melting	--	$15,275	--	--
Upgrading heat treat furnaces (Electric)	90.9	1,065	$ 10,000	9.4
Upgrading ladle heaters	240	790	3,000	3.8
Upgrading burn-out furnaces	12,684.1	41,860	80,000	1.9
TOTAL	13,015.0	$58,990	$ 93,000	1.57

TABLE 3

FOUNDRY "D"

PROJECTED ENERGY-EFFICIENCY RECORD

ALTERNATE 1

MONTH OR YEAR RECORDED			JUNE 1979 - MAY 1980	
UNITS OF PRODUCTION			500 NET GOOD TONS	
FUEL COSTS				
• Electricity		$	308,242.00	
• Natural Gas			67,515.00	
• Propane			--	
• Oil			--	
• Coke			--	
• Other			--	
	TOTAL	$	375,757.00	

ENERGY USED

• KWH	5,211,750	x 3,412 Btu	=	17,782.5	Btu x 10^6
• Mcf Gas	20,631.9		1/	20,631.9	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=		
• Gal. Oil		x 140,000 Btu	=		
• Coke - lb.		x 12,500 Btu	=		
•			=		
		TOTAL BTU		38,414.4	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{38{,}414.4}{500} = 76.83 \text{ Btu} \times 10^6\text{/Ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{375{,}757}{38{,}414.4} = \$\ 9.78 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{375{,}757}{500} = \$\ 751.50 \text{ Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 4

FOUNDRY "D"

PROJECTED ENERGY-EFFICIENCY RECORD

ALTERNATE 2

MONTH OR YEAR RECORDED			JUNE 1979 - MAY 1980	
UNITS OF PRODUCTION			500 NET GOOD TONS	
FUEL COSTS				
• Electricity		$	304,187.00	
• Natural Gas			67,515.00	
• Propane			--	
• Oil			--	
• Coke			--	
• Other			--	
	TOTAL	$	371,702.00	
ENERGY USED				
• KWH 5,211,750	x 3,412 Btu	=	17,782.5	Btu x 10^6
• Mcf Gas 20,631.9		1/	20,631.9	Btu x 10^6
• Gal. Propane	x 91,600 Btu	=	--	
• Gal. Oil	x 140,000 Btu	=	--	
• Coke - lb.	x 12,500 Btu	=	--	
•		=	--	
	TOTAL BTU		38,414.4	Btu x 10^6
ENERGY USED PER UNIT OF PRODUCTION				
(Million Btu) / (Units)	38.414.4 / 500	=	76.83	Btu x 10^6/Ton
COST PER MILLION BTU				
(Energy Cost) / (Million Btu)	371,702 / 38,414.4	= $	9.67	Cost/Btu x 10^6
COST PER UNIT OF PRODUCTION				
(Total Cost) / (Units)	371,702 / 500	= $	743.40	Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "D"

PROJECTED ENERGY-EFFICIENCY RECORD

ALTERNATE 3

MONTH OR YEAR RECORDED		JUNE 1979 - MAY 1980
UNITS OF PRODUCTION		500 NET GOOD TONS
FUEL COSTS		
• Electricity	$	297,964.00
• Natural Gas		67,515.00
• Propane		--
• Oil		--
• Coke		--
• Other		--
TOTAL	$	366,479.00

ENERGY USED

• KWH	5,211,750	x	3,412 Btu	=	17,782.5	Btu x 10^6
• Mcf Gas	20,631.9			1/	20,631.9	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	--	
• Gal. Oil		x	140,000 Btu	=	--	
• Coke - lb.		x	12,500 Btu	=	--	
•				=	--	
			TOTAL BTU		38,414.4	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{38,414.4}{500}$ = 76.83 Btu x 10^6/Ton

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{366,479}{38,414.4}$ = $ 9.54 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{366,479}{500}$ = $ 732.90 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 6

SECTION III

TABLE OF CONTENTS

FOUNDRY "E"

Page

FOUNDRY "E"

PART A

GENERAL DESCRIPTION

Steel castings including 15% high alloy and 20% low alloy, plain carbon steel are produced one shift per day with melting carried out from 8:00 a.m. - 10:00 p.m.

FACILITIES

Building area	107,500 SF
Manning total	230
Average shipments	3578.5 tons/year
Annual sales value	$9.5 million

MELTING

One electric arc furnace 10-ton capacity (3,600 kVA).

EQUIPMENT

Molding systems comprise squeezer units and no-bake methods with green sand systems sand mullers, 70 hp and 20 hp. A 10 hp blender is provided for no-bake. Cleaning room provides grinders, wheelabrators, and room blast capabilities. Material handling is mainly by overhead crane. Two HT furnaces are available. Core sand mixing is served by a 20 hp blender.

PART B

ENERGY USE TABLES

FOUNDRY "E"

ELECTRICAL POWER USAGE 2/

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT 1/	DEMAND CHARGE	GROSS BILL	NET BILL
SEPTEMBER 1978	792,000	3,600		28,860	(954)	3,411	32,271	$ 31,316.00
OCTOBER 1978	816,000	3,840		29,763	(992)	3,616	33,379	32,387.00
NOVEMBER 1978	804,000	3,600		29,234	(969)	3,411	32,645	31,676.00
DECEMBER 1978	720,000	3,480		26,330	(884)	3,310	29,640	28,831.00
JANUARY 1979	732,000	3,600		27,334	(914)	3,411	30,745	29,831.00
FEBRUARY 1979	876,000	3,600		33,152	(1,003)	3,411	36,563	35,560.00
MARCH 1979	744,000	3,840		28,584	(970)	3,616	32,200	31,230.00
APRIL 1979	780,000	4,440		30,168	(1,053)	4,129	34,297	33,244.00
MAY 1979	708,000	4,200		27,488	(994)	3,924	31,412	30,418.00
JUNE 1979	756,000	3,840		29,010	(973)	3,616	32,626	31,653.00
JULY 1979	672,000	3,600		25,903	(885)	3,411	29,314	28,429.00
AUGUST 1979	732,000	3,600		28,035	(926)	3,411	31,446	
TOTALS	9,132,000			343,861	(11,517)	42,677	386,538	$375,021

1/ INCLUDES CREDIT FOR VOLTAGE DISCOUNT AND POWER FACTOR ADJUSTMENT.

2/ RATE SCHEDULE A-7.

AVERAGE ELECTRICITY COST $= \frac{375.021}{9,132,000} =$ $ 0.04/KWH

TABLE 1

FOUNDRY "E"

ANNUAL GAS CONSUMPTION 2/

PERIOD	THERMS	BTU X 10^6	COST
SEPTEMBER 1978	41,113	4,111.3	$ 8,702.00
OCTOBER 1978	40,859	4,085.9	8,583.00
NOVEMBER 1978	43,717	4,371.7	9,194.00
DECEMBER 1978	36,122	3,612.2	7,582.00
JANUARY 1979	25,592	2,559.2	5,405.00
FEBRUARY 1979	43,013	4,301.3	9,156.00
MARCH 1979	51,407	5,140.7	10,937.00
APRIL 1979	42,276	4,227.6	8,984.00
MAY 1979	47,628	4,762.8	10,108.00
JUNE 1979	41,416	4,141.6	9,708.00
JULY 1979	41,416	4,141.6	9,708.00 1/
AUGUST 1979	29,925	2,992.5	7,280.00
TOTALS	484,484	48,448.4	$ 105,347.00

HEAT CONTENT OF GAS = 1,066 BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

1/ JULY BILL MISSING (USED JUNE FIGURES).

2/ 1978 COST BASED ON G.50 RATE SCHEDULE.
1979 COST BASED ON GN2 AND GN3 RATE SCHEDULE.

AVERAGE COST OF GAS $= \frac{105,347}{484,484} =$ $ 0.22 PER THERM

TABLE 2

FOUNDRY "E"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
SAND SYSTEM							
SCREEN					10		
AERATOR					10		
MULLER #3					20		
MULLER #2					40		
SAND SCRUBBER					40		
HAMMER MILL					20		
SHAKEOUT #1					40		
SAND ELEVATOR					15		
SUBTOTAL					195		
CLEANING ROOM							
GRINDER #1					25		
GRINDER #2					25		
BLOWER #1					30		
BLOWER #2					10		
WHEEL ABRATOR #1					10		
WHEEL ABRATOR #2					20		
WHEEL ABRATOR #3					20		
WHEEL ABRATOR #4					20		
SUBTOTAL					160		

TABLE 3

TABLE 3 (CONTINUED)

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
COMPRESSOR ROOM							
COMPRESSOR #1					125		
COMPRESSOR #2					125		
COMPRESSOR #3					150		
COMPRESSOR #4					100		
COMPRESSOR #5					125		
COMPRESSOR #6					125		
GENERATOR #1					75		
GENERATOR #2					100		
GENERATOR #3					150		
SUBTOTAL					1,075		
MISCELLANEOUS							
INCLINE CONVEYOR					15		
SHAKEOUT #2					10		
BLENDER					10		
3-TON CRANE					10		
BAGHOUSE #1					80		
BAGHOUSE #2					130		
BAGHOUSE #3					125		
BAGHOUSE #4					55		

TABLE 3

TABLE 3 (CONTINUED)

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	SERVICE
MISCELLANEOUS (Continued)							
CRANE #3					40		
CRANE #4					40		
CRANE #7					27		
SUBTOTAL					542		
TOTAL					1,972		
ARC FURNACE 10-Ton						3,600	

TABLE 3

FOUNDRY "E"

DESCRIPTION AND FLOW RATES OF GAS-FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
HEAT TREAT FURNACE #1	NORMAL-IZING	1	PREMIX	16	26	825	2,500
		3	O&G BURN.				
HEAT TREAT FURNACE #2	NORMAL-IZING	1	PREMIX	16	26		
		3	O&G BURN.			825	2,500
HEAT TREAT FURNACE #3	ANNEALING	1	PREMIX				
		7	O&G BURN.	16	26	2,300	7,000
HEAT TREAT FURNACE #4	CAR BOTTOM	1	O&G BURN.	16	26	1,300	4,000
CORE BAKE OVEN #1	COLEMAN	1	O&G BURN.	16	26	175	500
CORE BAKE OVEN #2	COLEMAN	1	O&G BURN.	16	26	175	500
AFTER BURN #1	CORE OVEN	1	ATMOS.	16	26	575	2,500
AFTER BURN #2	CORE OVEN	1	ATMOS.	16	26	575	2,500
LADLE HEATER #1		1	PREMIX, NA	16	26	1,500	3,000
LADLE HEATER #2		1	ATMOS.	16	26	200	500

TABLE 4

FOUNDRY "E"

DESCRIPTION AND FLOW RATES OF GAS-FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
LADLE HEATER #3		5	VENTURI	16	26	500	1,500
CUTTING TORCHES	HARRIS			16	26	50	200
WATER HEATERS		2	ATMOS.	16	26	50	100
SPACE HEATERS		2	ATMOS.	16	26	50	200
TOTALS						9,100	27,500

TABLE 4

FOUNDRY "E"

1979 ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED				SEPTEMBER 1978 THROUGH AUGUST 1979	
UNITS OF PRODUCTION				3,578.5 NET GOOD TONS SHIPPED	
FUEL COSTS					
• Electricity			$	375,021.00	
• Natural Gas				105,347.00	
• Propane				NONE	
• Oil					
• Coke				NONE	
• Other				NONE	
		TOTAL		480,368.00	
ENERGY USED					
• KWH 9,132,000	x	3,412 Btu	=	31,158.3	Btu x 10^6
• Mcf Gas 48,448	x		1/	48,448	Btu x 10^6
• Gal. Propane	x	91,600 Btu	=	NONE	
• Gal. Oil	x	140,000 Btu	=		
• Coke - lb.	x	12,500 Btu	=	NONE	
•			=		
		TOTAL BTU		79,606	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}\ 79{,}606}{\text{(Units)}\ 3{,}578.5} = 22.24$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}\ 480{,}368}{\text{(Million Btu)}\ 79{,}606} = 6.03 \quad \text{Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}\ 480{,}368}{\text{(Units)}\ 3{,}578.5} = 134.24 \quad \text{Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "E"

ENERGY - EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED	1980 PROJECTED (ELECTRICAL ONLY)
UNITS OF PRODUCTION	3,578
	NET GOOD TONS SHIPPED
FUEL COSTS	
• Electricity	$ 551,696.00
• Natural Gas	105,347.00
• Propane	NONE
• Oil	"
• Coke	"
• Other	"
TOTAL	$ 657,043.00

ENERGY USED

• KWH	9,132,000	x	3,412 Btu	=	31,049	Btu x 10^6
• Mcf Gas	48,448	x		1/	48,448	
• Gal. Propane		x	91,600 Btu	=	NONE	
• Gal. Oil		x	140,000 Btu	=	"	
• Coke - lb.		x	12,500 Btu	=	"	
•				=	"	
			TOTAL BTU		79,497	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{79,497}{3,578}$ = 22.22

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{657,043}{79,497}$ = 8.26 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{657,043}{3,578}$ = 183.6 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calender year costs and are based on 1979 energy consumption with "1980" billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of demand controls.

3/ Allother energy tests are 1979 rates.

TABLE 6

PROJECTED ELECTRICAL COST FOR 1980 RATE A-8

Month	Kilowatt Demand	Demand Charge	Kilowatt Hours	Energy Cost	Fuel Adj. Cost .01052	Total Cost
Jan.	3,600	18,068	732,000	19,729	7,700	45,497
Feb.	3,600	18,068	876,000	20,340	9,215	47,623
March	3,840	19,273	744,000	20,022	7,826	47,121
April	4,440	22,284	780,000	17,957	8,205	48,446
May	4,200	21,080	708,000	18,263	7,448	47,691
June	3,840	19,273	756,000	21,782	7,953	49,008
July	3,600	18,068	672,000	18,580	7,069	43,717
Aug.	3,600	18,068	732,000	19,522	7,700	45,290
Sept.	3,600	18,068	792,000	17,738	8,331	44,137
Oct.	3,840	19,273	816,000	18,874	8,584	46,731
Nov.	3,600	18,068	804,000	16,796	8,458	43,322
Dec.	3,480	17,466	702,000	18,262	7,385	43,113
		$227,057		227,865	95,875	551,696

Average Electrical Cost = $\frac{551,696}{9132.00}$ .06 per kwh

TABLE 7

PART C

PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE E

CASTING METAL Steel Castings

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	941.1	301.6	N/A	N/A
FEBRUARY	711.1	290.5		
MARCH	846.2	265.3		
APRIL	789.5	369.2		
MAY	828.3	284.6		
JUNE	754.6	218.2		
JULY	725.6	330.4		
AUGUST	817.6	293.9		
SEPTEMBER	587.7	397.5		
OCTOBER	771.1	275.8		
NOVEMBER	771.1	275.7		
DECEMBER	771.1	275.8		
TOTALS	9,315	3,578.5		$9,500,000

AVERAGE MELT TONS/DAY = 42.34

REPORTED % SCRAP N/A

REPORTED % MELT LOSS N/A

AVERAGE FOUNDRY YIELD % 38.42

AVERAGE SALES VALUE/LB.

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS

FOUNDRY E

KILOWATT DEMAND LOAD PROFILE
ARC FURNACES & GENERAL PLANT SERVICE

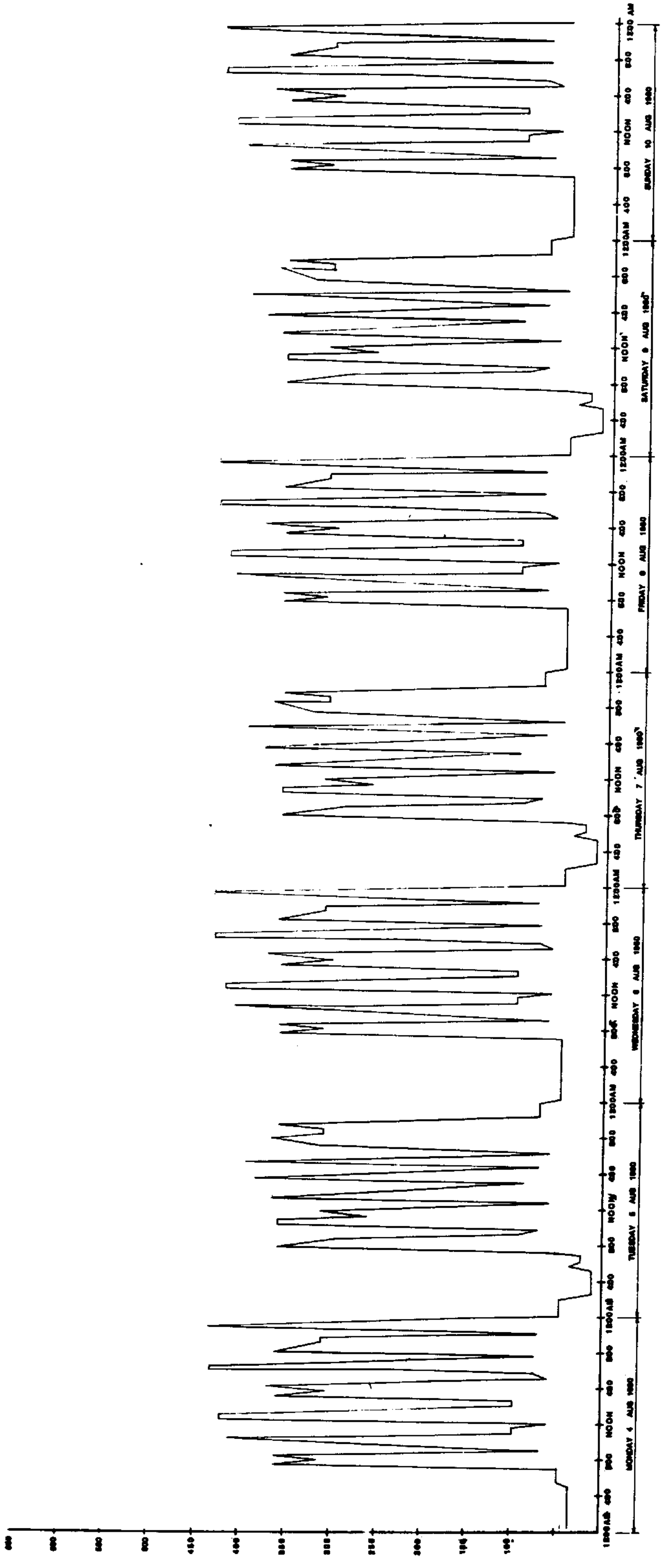


FIGURE 1

OPERATIONAL DATA FACT SHEET

ARC FURNACE DATA

Furnace make ___N/A___

Shell Dia. ___N/A___ FEET

Depth ___N/A___ INCHES

Capacity ______ TONS

Electrode Dia. ___N/A___ inches

Transformer ___3,600___ KVA

Primary ___N/A___ VOLT

Taps 1st ______ VOLT

2nd ______ VOLT

3rd ______ VOLT

Output ______ Tons/YR

Alloy ___STEEL___

Melt cycle ___N/A___ minutes

Heat size ___N/A___ tons

Heats per day ___N/A___

Taping temperature ___N/A___ ^oF

No. of Back charges ___N/A___

No. of slag cycles ___N/A___

Blow down cycles O_2 ___N/A___ minutes

C ______ minutes

Type of fume collection:

Furnace pressure ___N/A___ oz

Exhaust ___N/A___ CFM

Water Cooling ___N/A___ GPM

Roof ___N/A___, Glan ___N/A___, Slag Door ___N/A___, Basel ___N/A___,

Type of refractory lining ___N/A___

TABLE 1

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES

HEAT TREATING UNITS NO. 1 AND 2

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	MODEL N/A
SIZE N/A WFT.	TYPE PREMIX SIZE 2,500,000 BTU/HR
CAPACITY N/A LBS.	FUEL NATURAL GAS - OIL STANDBY
TYPE OF LINING	RECUPERATOR MAKE NONE
WALL THICKNESS INCH	MODEL -- TEMP -- °F
BLOWER MAKE N/A	TYPE -- SIZE --
MODEL N/A	CONTROLS MAKE --
SIZE -- CFM. PRESS -- "WG	TYPE --
VOLT -- HP --	

TYPE OF HEAT TREAT CYCLE ALLOY

HEAT TREAT CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
-COOL DOWN N/A HRS	SHELL MEAN TEMPERATURE N/A °F
CYCLES PER WEEK N/A	FURNACE PRESSURE N/A "WC
TEMPERATURE 2,200 °F	
AVERAGE LOAD N/A LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH -- AIR, -- H20 -- OIL	N/A % CO_2
QUENCH TEMPERATURE -- °F	FUEL CONSUMPTION N/A THERMS/CYCLE

WALL AREA N/A SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE VARIES °F

EXTERNAL SURFACE AREA N/A SQ.FT.

ENERGY COST/THERM $ 0.22

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

TABLE 2

TABLE 2 (CONTINUED)

HEAT TREATING UNIT NO. 3	
FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	MODEL N/A
SIZE N/A WFT.	TYPE PREMIX SIZE 7,000,000 BTU/HR
CAPACITY N/A LBS.	FUEL NATURAL GAS - OIL STANDBY
TYPE OF LINING N/A	RECUPERATOR MAKE NONE
WALL THICKNESS N/A INCH	MODEL -- TEMP -- °F
BLOWER MAKE N/A	TYPE -- SIZE --
MODEL N/A	CONTROLS MAKE --
SIZE -- CFM. PRESS -- "WG	TYPE --
VOLT -- HP --	
TYPE OF HEAT TREAT CYCLE ALLOY	
HEAT TREAT CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH °F LOW °F
-COOL DOWN N/A HRS	SHELL MEAN TEMPERATURE °F
CYCLES PER WEEK N/A	FURNACE PRESSURE "WC
TEMPERATURE 1,100 TO 1,750 °F	
AVERAGE LOAD N/A LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH -- AIR, -- H2O -- OIL	N/A % CO_2
QUENCH TEMPERATURE N/A °F	FUEL CONSUMPTION N/A THERMS/CYCLE

WALL AREA	N/A	SQ.FT.
WALL TEMPERATURE HOT FACE T_1	N/A	°F
WALL TEMPERATURE COLD FACE T_2	N/A	°F
AMBIENT TEMPERATURE	VARIES	°F
EXTERNAL SURFACE AREA	N/A	SQ.FT.
ENERGY COST/THERM $	0.22	
HEAT TREAT LOADS/DAY	N/A	
HEAT TREAT LOADS/YEAR	N/A	

TABLE 2

TABLE 2 (CONTINUED)

HEAT TREATING UNIT NO. 4

FURNACE MAKE N/A	BURNER MAKE N/A
MODEL N/A	MODEL N/A
SIZE 8' x 12' WFT.	TYPE O&G SIZE 4,000,000 BTU/HR
CAPACITY N/A LBS.	FUEL NATURAL GAS AND OIL STANDBY
TYPE OF LINING N/A	RECUPERATOR MAKE NONE
WALL THICKNESS N/A INCH	MODEL -- TEMP -- °F
BLOWER MAKE N/A	TYPE -- SIZE --
MODEL N/A	CONTROLS MAKE --
SIZE -- CFM. PRESS -- "WG	TYPE --
VOLT -- HP --	

TYPE OF HEAT TREAT CYCLE ALLOY

HEAT TREAT CYCLE - HEATUP N/A HRS	FUEL/AIR RATIO N/A
- SOAK N/A HRS	FLUE TEMPERATURE HIGH N/A °F LOW N/A °F
-COOL DOWN N/A HRS	SHELL MEAN TEMPERATURE N/A °F
CYCLES PER WEEK	FURNACE PRESSURE N/A "WC
TEMPERATURE 1,700 °F	
AVERAGE LOAD N/A LBS	FLUE ANALYSIS (HIGH) N/A % CO
CASTING N/A LBS	N/A % O_2
BASKETS N/A LBS	N/A % CO_2
STOOLS N/A LBS	LOW N/A % CO
LOAD DENSITY N/A LBS/WFT	N/A % O_2
QUENCH -- AIR, -- H2O -- OIL	N/A % CO_2
QUENCH TEMPERATURE -- °F	FUEL CONSUMPTION N/A THERMS/CYCLE

WALL AREA N/A SQ.FT.

WALL TEMPERATURE HOT FACE T_1 N/A °F

WALL TEMPERATURE COLD FACE T_2 N/A °F

AMBIENT TEMPERATURE VARIES °F

EXTERNAL SURFACE AREA N/A SQ.FT.

ENERGY COST/THERM $ 0.22

HEAT TREAT LOADS/DAY N/A

HEAT TREAT LOADS/YEAR N/A

TABLE 2

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

(LADLE NO. 1)

LADLE CAP TONS N/A HEAT CYCLES/DAY N/A

LADLE AREA INSIDE N/A SQ FT. LINING THICKNESS N/A

COVERED No TYPE OF LINING Conventional F.B.

INSIDE TEMP N/A °F OUTER SHELL TEMP N/A °F

AMBIENT TEMP Varies °F

GAS USAGE/HR 1,500* CU FT. CO_2 READING N/A

COMBUSTION AIR N/A CFM PRESSURE N/A WG

PREHEAT CYCLE TIME N/A HRS FLUE TEMP N/A °F

REFRACTORY K VALUE N/A RS VALUE N/A

BLOWER HP None RECUPERATOR EFFCY None

FUEL COST/THERM $ 0.22 ANNUAL USE 1,728** BTU x 10^6

NUMBER OF UNITS IN USE One

* This is an average flow rate; maximum flow rate is 3,000 CFH which is extracted from gas company records.

** Based on an average preheat cycle of 4 hours per day - 6 days per week.

TABLE 3

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

(LADLE NO. 2)

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	N/A
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	No	TYPE OF LINING	Conventional F.B.
INSIDE TEMP	N/A °F	OUTER SHELL TEMP	N/A °F
AMBIENT TEMP	Varies °F		
GAS USAGE/HR	200* CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A °F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	None	RECUPERATOR EFFCY	None
FUEL COST/THERM $	0.22	ANNUAL USE	230.4** BTU x 10^6
NUMBER OF UNITS IN USE			

* Average flow rate.

** Based on 4 hours per day - 6 days per week.

TABLE 3

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

(LADLE NO. 3)

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	N/A
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	No	TYPE OF LINING	Conventional F.B.
INSIDE TEMP	N/A ^{o}F	OUTER SHELL TEMP	N/A ^{o}F
AMBIENT TEMP	Varies ^{o}F		
GAS USAGE/HR	500* CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A ^{o}F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	None	RECUPERATOR EFFCY	None
FUEL COST/THERM $	0.22	ANNUAL USE	756** BTU x 10^6
NUMBER OF UNITS IN USE	One		

* Average flow rate.

** Based on 4 hours per day - 6 days per week.

TABLE 3

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this Study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this Study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed form utility company computerized data for 15 to 30 minute periods.

PART E

ENERGY CONSERVATION POTENTIAL

ELECTRICAL ENERGY COST SAVINGS

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Based on a sample billing period of one year, the cost reduction potential is:

1. Demand Control

	Total
Normal melting demand cost 1/	$127,142
Demand limited demand cost 1/	108,480
Annual Savings	$ 18,662

$$\text{Percent savings} = \frac{\text{T'reduction in cost}}{\text{T'normal cost of melting}} = 14.7\%$$

For graphic illustration of methodology used in calculating electrical savings see Figure 1.

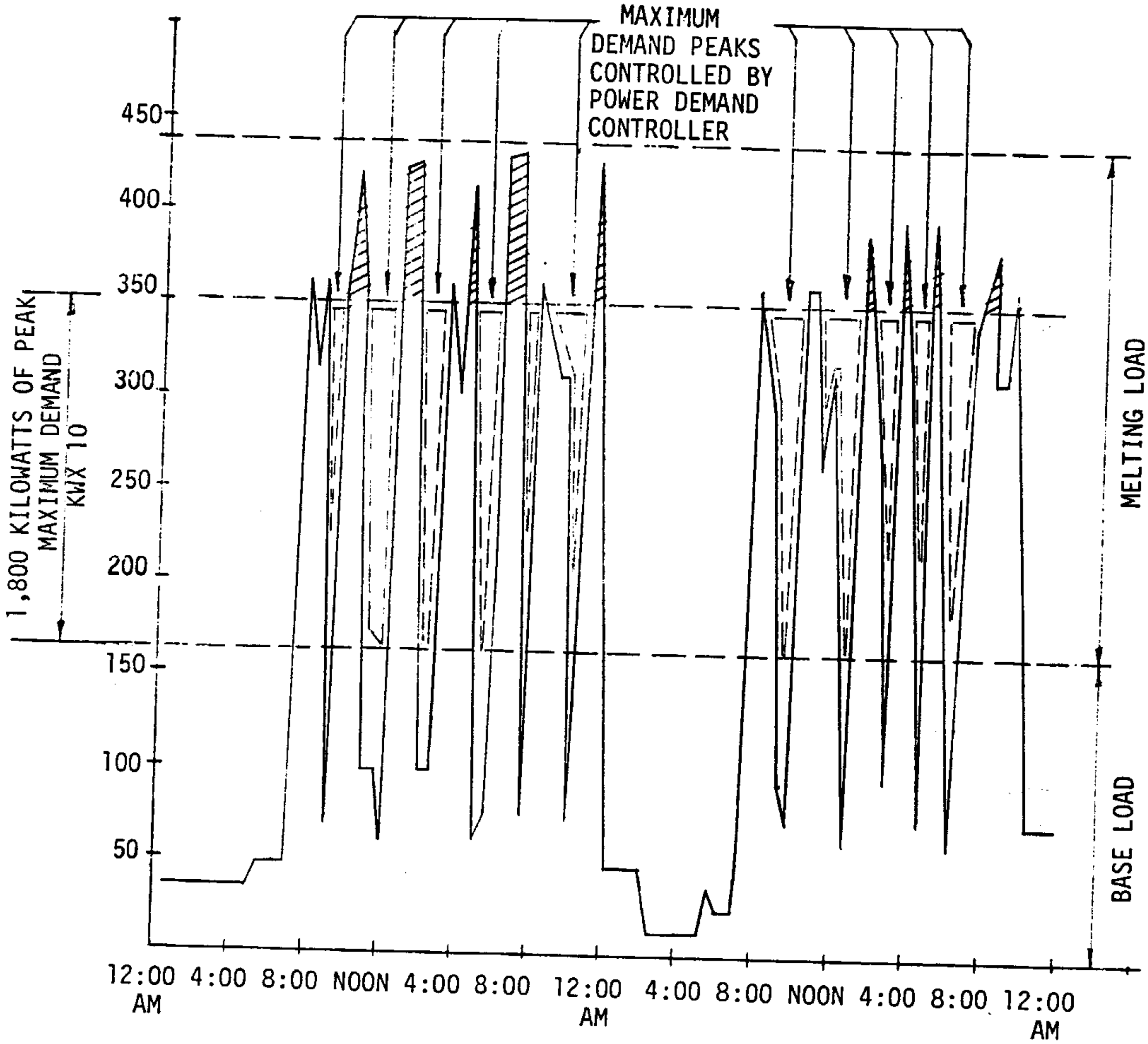
1/ Work Sheet Table-1

DEMAND CONTROLLING

NORMAL MELTING COST			DEMAND CONTROLLING COST			
Month	Kilowatt Demand	Demand Charge	Kilowatt Demand	Demand Charge	Savings	%
Jan.	2016	10,118	1800	9034	1084	10.7
Feb.	2016	10,118			1084	10.7
March	2150	10,790			1756	16.3
April	2486	12,477			3443	27.6
May	2352	11,805			2771	23.5
June	2150	10,790			1756	16.3
July	2016	10,118			1048	10.7
Aug.	2016	10,118			1048	10.7
Sept.	2016	10,118			1084	10.7
Oct.	2150	10,790			1756	16.3
Nov.	2016	10,118			1084	10.7
Dec.	1949	9,782			748	7.6
		127,142		108,480	18,662	

Potential yearly saving (average) = 15%
Based on a maximum demand of 1,800 kW.

TABLE 1



KILOWATT DEMAND PROFILE
INDUSTRIAL BILLING RATE

FIGURE 1

Upgrading Heat Treat Furnaces

Total gas energy consumed per year	=	484,484 therms/yr
Total annual gas cost	=	$ 105,347.00
Average gas cost	=	$ 0.22/therm

Approximately 80% of the total gas consumption is attributable to heat treat operations; this amounts to (484,484 therms x 0.8) 387,587 therms.

A large amount of energy can be conserved by upgrading the heat treat furnaces in the following areas:

- Install ceramic fiber lining
- Install high-efficiency gas burners with air/fuel ratio controls
- Install recuperators for combustion air preheating
- Install furnace pressure controls
- Repair all cracks

Approximately 56% increase in overall furnace efficiency can be realized by performing above functions.

Potential energy savings:

(387,587 therms x 0.56) = 217,048 therms/yr

Potential cost savings (217,048 x 0.22) = $ 47,750.00/yr

Upgrading Ladle Heaters

Approximate energy consumed in ladle heating:

• Ladle No. 1	756×10^6 Btu/yr
• Ladle No. 2	230×10^6 Btu/yr
• Ladle No. 3	$1{,}728 \times 10^6$ Btu/yr
TOTAL	$2{,}714 \times 10^6$ Btu/yr
	OR 27,140 therms/yr

Significant energy savings can be realized by upgrading ladle heaters in the areas:

- Install ceramic fiber insulation
- Install ladle heater covers
- Install high-efficiency burner system

Approximately 40% increase in overall ladle thermal efficiency is possible, therefore:

Potential energy savings:

(27,140 therms x 0.4) = 10,856 therms/yr

Potential cost savings:

(10,856 x 0.22) = $ 2,388.00/yr

PART F

ECONOMIC ANALYSIS

PART F

ECONOMIC ANALYSIS

Payback period is calculated as follows:

$$\frac{\text{Total capital investment}}{\text{Gross Energy cost reduction/year}} = \underline{\hspace{2cm}}\text{years}$$

Payback years for individual projects are listed in Part "G" based on order of magnitude costs as follows:

• Demand Controller	$	10,000.00
• Upgrading Heat treat furnace	$	100,000.00
• Upgrade ladle heaters	$	12,000.00
		122,000.00

The following conditions could lower the anticipation pay each period considerably:

- Present day equipment costs used (However the energy cost savings is based on 1979 calender year average energy cost, except for electricity which is based on 1980 rates).

- No credit taken for government tax credit for installation of energy savings devices.

- Calculation of return on investment utilizies life cycle costing methods, which take into account depreliation, cost of money and excalation of energy test over the life time of the equipment, could possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G
SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Demand controllers		18,662	10,000	.62
Upgrading heat treat furnaces	21,705	47,750	100,000	2.1
Upgrading ladle heaters	1,086	2,388	12,000	5.0
TOTAL	22,791	68,800	122,000	1.77

Off-Peak Melting and Load Shifting not applicable to this foundry.

FOUNDRY E

PROJECTED ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED	FUTURE
UNITS OF PRODUCTION	3,578.5 NET GOOD TONS SHIPPED
FUEL COSTS	
• Electricity	$ 533,034.00 2/
• Natural Gas	55,209.00
• Propane	NONE
• Oil	
• Coke	NONE
• Other	NONE
TOTAL	588,243.00

ENERGY USED

• KWH 9,132,000.00	x	3,412 Btu	=	31,049.00	Btu x 10^6
• Mcf Gas 25,657.00			1/	25,657.00	
• Gal. Propane	x	91,600 Btu	=	NONE	
• Gal. Oil	x	140,000 Btu	=		
• Coke - lb.	x	12,500 Btu	=	NONE	
•			=		
		TOTAL BTU		56,661.00	

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{56,661}{3,578.5}$ = 15.83 Btu x 10^6/ton

COST PER MILLION BUT

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{588,243}{56,661}$ = 10.38 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{588,243}{3,578.5}$ = 164.4 Cost/Unit

1/ 1 Mcf = 1,000 cu. ft./hr - See Gas Bill for Btu content/cu. ft.

2/ Projected 1980 electrical cost - Alternate - 1

SECTION III

TABLE OF CONTENTS

FOUNDRY "F" Page

FOUNDRY "F"

PART A

GENERAL DESCRIPTION

Specialty alloy and Master Melt metals producer. Casting capability in centrifugal and investment methods. Operation 2 and 3 shifts per day.

Facilities

Building Area	138,000 square feet
Manning Total	440
Average Shipments	9,600 Tons/year
Annual Sales (Fiscal)	$45.6 Million
Annual Sales (Current)	$47.5 Million

Melt Furnaces

Capacities:	3 x 3,600 lbs.	Induction
	1 x 2,300 lbs.	Induction
	2 x 1,000 lbs.	Induction
	2 x 900 lbs.	Induction
	2 x 700 lbs.	Arc
	2 x 500 lbs.	Arc
	1 x 400 lbs.	Induction
	1 x 8,000 lbs.	Arc
	2 x 5,500 lbs.	Vacuum

FURNACE SIZE - KW

	Steel	Iron	Alloy	Total KW
Arc Furnaces	1 x 3,500	2 x 225*	-	3,950
Induction	1 x 175*	1 x 175	1 x 50	400
Induction	1 x 300*	-	2 x 750	1,800
Induction	-	-	3 x 500	1,500
	3,975	625	3,050	7,650

* Centrifugal Casting Department.

N'Gas Fired Equipment

Type	Application		No.	BTU/Hr.
Small	Open heater	150,000	1	150,000
Small	Spinner mold heaters	<350,000	14	3,650,000
Large	Spinner mold heaters	>500,000	10	6,250,000
Small	Ladle and tundish heaters	<300,000	16	3,920,000
Large	Ladle and tundish heaters	>500,000	6	4,000,000
Blu-Surf	Burners(ladles etc)	<500,000	7	1,410,000
Large	Misc. burners		5	2,300,000
Large	Nitricast heaters		3	800,000
Small	Ovens and misc. drying equipment		21	5,050,000
	Shell core m/c		1	250,000
	Heat Treat Furnace		10	10,350,000
	Pit Ovens		11	5,940,000
	Total Load @ 100%			44,070,000

Utilities

Average N'gas cost per month - $15,600

Average Electricity power cost per month - $71,000

Average Other fuels and gases -

- Oxygen - 139,800 cu. ft./month
- Argon - 78,600 cu. ft./month
- Diesel - 1,150 gals./month @ 150,000 BTU/gl.
- Propane - 3,500 gals./month ($1,600)

Water usage - 1.9 Million cu. ft. per year

Average power costs as percent of sales; Fiscal year 1.8%

Average power costs as percent of sales; Current year 2.2%

Auxiliary Services

Compressed air: 1,200 CFM (97 hp)

Environmental:

- Bag houses 40,320 CFM
- Roof fans 31
- Man cooler fans 12
- A.C. units 20

PART B

ENERGY USE TABLES

FOUNDRY "F"

ELECTRICAL POWER USAGE

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE 1/	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE 2/	GROSS BILL	NET BILL
JANUARY 1979	1,186,400	8,060		2,623	33,071	16,060	-	51,754
FEBRUARY 1979	1,561,600	8,012		5,008	35,926	23,031	-	63,965
MARCH 1979	1,551,200	8,608		4,949	35,744	23,396	-	64,089
APRIL 1979	1,313,600	8,588		4,291	30,428	23,455	-	58,174
MAY 1979	1,446,400	8,176		4,668	33,568	23,146	-	61,382
JUNE 1979	1,471,200	11,433		4,736	34,167	28,099	-	67,002
JULY 1979	1,404,800	11,424		4,537	34,588	33,392	-	72,517
AUGUST 1979	1,401,600	11,280		4,591	33,944	32,763	-	71,298
SEPTEMBER 1979	1,474,400	10,374		4,813	35,598	24,885	-	65,296
OCTOBER 1979	1,685,600	9,705		5,467	40,779	24,472		70,718
NOVEMBER 1979	1,761,600	11,549		5,583	54,377	32,566		92,526
DECEMBER 1979	1,868,800	9,836		5,853	63,202	24,538		93,593
TOTAL	18,127,200	117,045		57,119	465,392	309,803		832,314

1/ ENERGY CHARGE BASED ON HIGH VOLTAGE SERVICE

2/ DEMAND CHARGES INCLUDE CUSTOMER CHARGE AND POWER FACTOR ADJUSTMENT

AVERAGE COST OF ELECTRICITY $= \frac{832,314}{18,127,200} =$ \$ 0.046/KWH

TABLE 1

FOUNDRY "F"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
JANUARY 1979	55,460	5,546	13,892.19
FEBRUARY 1979	67,080	6,708	16,802.13
MARCH 1979	54,310	5,431	14,856.32
APRIL 1979	63,370	6,337	15,873.05
MAY 1979	57,760	5,776	14,468.17
JUNE 1979	50,230	5,023	12,582.47
JULY 1979	60,070	6,007	15,046.65
AUGUST 1979	53,590	5,359	13,423.89
SEPTEMBER 1979	52,560	5,256	14,006.21
OCTOBER 1979	59,840	5,984	17,221.01
NOVEMBER 1979	74,960	7,496	21,571.03
DECEMBER 1979	59,940	5,994	17,134.70
TOTALS	709,170	70,917	186,877.82

HEAT CONTENT OF GAS = BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{186,877.82}{709,170}$ = \$ 0.26 PER THERM

TABLE 2

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT
(MELT FURNACES ONLY)

EQUIPMENT	TYPE	CAPACITY LBS.	OPERATION HRS/DAY	DAYS/MO	H.P.	KW	SERVICE
FURNACE NO. 1	VACUUM INDUCTION	6,000				750	
FURNACE NO. 2	VACUUM INDUCTION	6,000				750	
FURNACE NO. 3	3-PHASE ARC.	8,000				3,500	
FURNACE NO. 4	INDUCTION	3,600				500	
FURNACE NO. 5	INDUCTION	3,600				500	
FURNACE NO. 6	INDUCTION	3,600				500	
FURNACE NO. 7	INDUCTION	600				175	
FURNACE NO. 8	INDUCTION	2,300				175	
FURNACE NO. 9	INDUCTION	1,400					
FURNACE NO. 10	INDUCTION	900				300	
FURNACE NO. 11	INDUCTION	400					
FURNACE NO. 12	DETROIT ARC	500				225	
FURNACE NO. 13	DETROIT ARC	500				225	
FURNACE NO. 14	DETROIT ARC	700				225	
FURNACE NO. 15	DETROIT ARC	700				225	
FURNACE NO. 16	DETROIT ARC	1,000				225	
FURNACE NO. 17	VACUUM INDUCTION					50	
TOTAL						8,325	

TABLE 3

FOUNDRY "F"

DESCRIPTION AND FLOW RATES OF GAS-FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
BUILDING #1							
SPINNERS (4)		1EA	ECLIPSE			800	
FURNACES (3)	INDUCTION	3	ECLIPSE			1,500	
MOLD HEATER						1,000	
SPOUT HEATER			ECLIPSE			200	
LADLE HEATERS (3)			ECLIPSE			1,500	
BLU-SURF						860	
MOLD HEATERS (3)						800	
MOLD OVEN						1,000	
SUBTOTAL	-------	-------	-------	-------	-------	7,660	
BUILDING #2							
MOLD HEATERS (3)						600	

TABLE 4

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
SUBTOTAL	-------	-------	-------	-------	-------	5,940	
OUTSIDE							
HT. OVEN #21		10				1,500	
HT. OVEN #22		8				1,000	
SOUTH FURNACE		8				500	
NORTH FURNACE		4				500	
HT. OVEN #24		8	J. KNAPP			800	
HT. OVEN #25		2				700	
HT. OVEN #26		2				700	
HT. OVEN #27		16				1,600	
HT. OVEN #28		18				1,800	
HT. OVEN #29		4	N. AMERICAN			1,250	

TABLE 4

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
SUBTOTAL	---	---	---	---	---	5,940	
OUTSIDE							
HT. OVEN #21		10				1,500	
HT. OVEN #22		8				1,000	
SOUTH FURNACE		8				500	
NORTH FURNACE		4				500	
HT. OVEN #24		8	J. KNAPP			800	
HT. OVEN #25		2				700	
HT. OVEN #26		2				700	
HT. OVEN #27		16				1,600	
HT. OVEN #28		18				1,800	
HT. OVEN #29		4	N. AMERICAN			1,250	

TABLE 4

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
SUBTOTAL	----------	----------	----------	----------	----------	10,350	
BUILDING 10							
?		3				1,050	
BLU-SURF (3)		3				550	
LADLE HEATERS (3)						2,500	
PIG HEATER						400	
TUNDISH HEATER						400	
FURNACE ROOF HEATER						700	
SUBTOTAL	----------	----------	----------	----------	----------	5,600	
BUILDING #11							
OVEN	PROBACK					300	
OPEN HEATERS						150	

TABLE 4

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
SHELL CORE	HUTCHINSON					250	
PIG PIPE HEATERS						600	
SUBTOTAL	------	------	------	------	------	1,300	
BUILDING #12							
TUNDISH OVEN		10				1,000	
FIREWALLS		2 EA				1,000	
?		3				750	
SUBTOTAL	------	------	------	------	------	2,750	
BUILDING #14							
TUNDISH FIREWALLS (2)		2 EA				1,000	
TUNDISH PIPE HEATERS (4)						720	
MOLD OVEN		1				1,500	

TABLE 4

TABLE 4 (CONTINUED)

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
?		2				700	
INVEST OVEN		8				800	
TOTALS						43,470	

TABLE 4

FOUNDRY "F"

1979 ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED		1979
UNITS OF PRODUCTION		9,600 TONS SHIPPED
FUEL COSTS		
• Electricity	$	832,314.00
• Natural Gas		186,877.82
• Propane		NONE
• Oil		NONE
• Coke		NONE
• Other		NONE
TOTAL	$	1,019,191.82

ENERGY USED

• KWH	18,127,200	x	3,412 Btu	=	61,850	Btu x 10^6
• Mcf Gas	70,197	x		1/	70,917	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	NONE	
• Gal. Oil		x	140,000 Btu	=	NONE	
• Coke - lb.		x	12,500 Btu	=	NONE	
•				=		
			TOTAL BTU		132,767	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{132,767}{9,600} = 13.82 \text{ Btu} \times 10^6/\text{TON}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{1,019,192}{132,047} = \$\ 7.72 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{1,019,192}{9,600} = \$\ 106.17 \text{ Cost/TONS}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "F"

ENERGY - EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED				1980 PROJECTED (ELECTRICAL ONLY)
UNITS OF PRODUCTION				9,600 NET GOOD TONS PER YEAR
FUEL COSTS				
• Electricity			$	1,170,233
• Natural Gas				186,877.82
• Propane				NONE
• Oil				NONE
• Coke				NONE
• Other				NONE
		TOTAL	$	1,357,110

ENERGY USED

• KWH	18,127,200	x	3,412 Btu	=	61,850 Btu x 10^6
• Mcf Gas	70,917	x		1/	70,917 Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	NONE
• Gal. Oil		x	140,000 Btu	=	NONE
• Coke - lb.		x	12,500 Btu	=	NONE
•				=	NONE
			TOTAL BTU		132,767 Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{132,767}{9,600}$ = 13.82 Btu X 10^6/TON

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{1,357,110}{132,767}$ = $ 10.22 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{1,357,110}{9,600}$ = $ 141.36 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ THE ELECTRICAL COST SHOWN REPRESENTS 1980 CALENDAR YEAR COSTS AND ARE BASED ON 1979 ENERGY CONSUMPTION WITH 1980 "TIME OF DAY" BILLING RATES APPLIED. THE PROJECTED ELECTRICAL COST IS USED AS A BASE FOR CALCULATING COST SAVINGS BY IMPLEMENTATION OF DEMAND LIMITING AND CONTROL.

3/ ALL OTHER ENERGY COSTS ARE 1979 RATES.

TABLE 6

PART C

PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE F

CASTING METAL Alloy Steels

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	N/A	N/A	N/A	N/A
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
TOTALS	10,140	9,600		$45,600,000

AVERAGE MELT TONS/DAY = 42.1

REPORTED % SCRAP N/A

REPORTED % MELT LOSS N/A

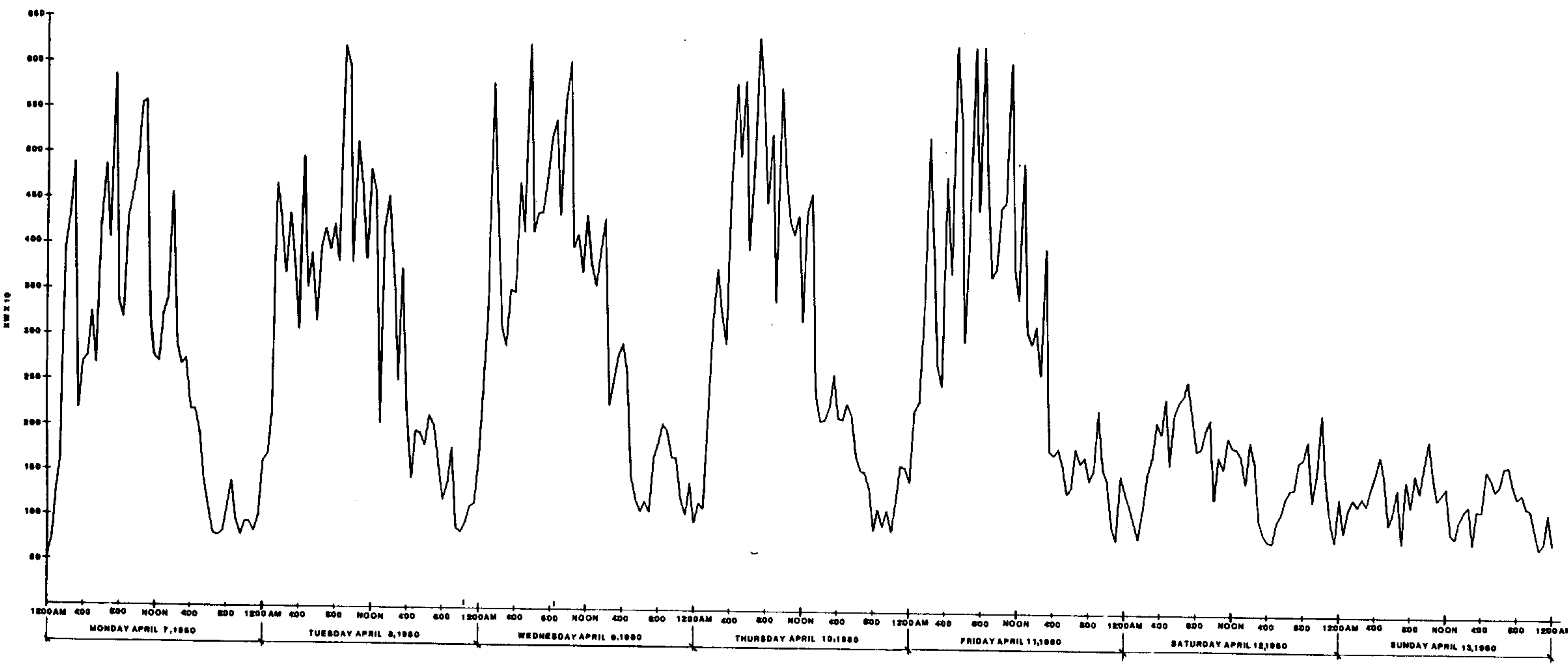
AVERAGE FOUNDRY YIELD % 94.7

AVERAGE SALES VALUE/LB.

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE (WINTER)
ARC FURNACES, INDUCTION FURNACES & GENERAL PLANT SERVICE

FOUNDRY F

FIGURE 1

OPERATIONAL DATA FACT SHEETS

ELECTRIC MELT FURNACES

FURNACE NUMBER	TYPE	MELT CAPACITY LBS.	MELT PER DAY LBS.	MELT DOWN HRS.	POURING TEMPERATURE °F	CYCLE TIME HRS.
1	Vacuum Induction	5,500	N/A	N/A	N/A	6 to 8
2	Vacuum Induction	5,500	N/A	N/A	N/A	5 to 7
3	3-phase Arc	8,000	N/A	3.5	N/A	N/A
4	Induction	3,600				
5	Induction	3,600	50,000 2/	4.0	N/A	N/A
6	Induction	3,600				
7						
8	Induction	2,300	N/A	1.5 to 2.5	2,400-2,950	N/A
9	Induction	1,400	N/A	N/A	N/A	N/A
10	Induction	900	N/A	1.5 to 2.5	2,400-2,950	N/A
11	Induction	400	N/A	1.5 to 2.5	2,400-2,950	N/A
12	Detroit Arc	500				
13	Detroit Arc	500				
14	Detroit Arc	700	18,000	1.0 to 1.5	N/A	N/A
15	Detroit Arc	700				
16	Detroit Arc	1,000				
17	Vacuum Induction	N/A	N/A	N/A	N/A	N/A

1/ See Table 3, Part B, for electrical data.

2/ Based on 3-shift operation.

TABLE 1

OPERATIONAL DATA FACT SHEET

HEAT TREAT FURNACES

FURNACE NUMBER	SIZE	CAPACITY	TYPE BURNER	NUMBER OF BURNERS	BTU/HR X 10^6	TYPE OF LINING	CYCLE TIME	CYCLES PER WEEK	FLUE TEMP.	FLUE GAS CO_2	FUEL USE PER CYCLE
1	N/A	N/A	PREMIX	10	1.5	CONV.	N/A	N/A	N/A	N/A	N/A
2				8	1.0						
3				8	0.5						
4				4	0.5						
5				8	0.8						
6				2	0.7						
7				2	0.7						
8				16	1.6						
9				18	1.8						
10				4	1.25						
TOTAL					10.35						

TABLE 2

OPERATIONAL DATA FACT SHEET

LADLE HEATERS

LADLE HEATER NUMBER	TYPE	CAPACITY	SIZE	TYPE OF LINING	COVERED	GAS BTU/HR	OPERATING CYCLE
1		N/A	N/A	N/A	No	500,000	N/A
2	Eclipse					500,000	
3						500,000	
4	Innocul.					300,000	
5	Fire wall					200,000	
6						800,000	
7	Heat X Tractor					800,000	
8						800,000	
9	Fire wall					500,000	
10	Fire wall					500,000	
11	Fire wall					500,000	
12	Fire wall					500,000	
TOTAL						6.4×10^6	

REMARKS:

TABLE 3

PART E

ENERGY CONSERVATION POTENTIAL

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this Study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this Study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15 to 30 minute periods.

Electrical Energy Cost Savings

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Percentage of total energy usage by electrical load

$$= \frac{\text{Electrical Energy}}{\text{Total Energy}} = \frac{61{,}850 \times 10^6}{132{,}047 \times 10^6} \times 100 = 47\%$$

1/ Melting energy usage @ 54% = 9,701,109 KWH

Based on a sample billing period of one month each at summer and winter rate schedules, the cost reduction potential is;

1. Demand Control

	Summer	Winter	Total
2/ Normal melting cost	61,066	55,747	116,813
3/ Demand limited cost	60,028	53,926	113,954
Reduction			2,859

$$\text{Percent savings} = \frac{\text{Reduction in cost}}{\text{Normal cost of melting}} = \underline{2.4\%}$$

∴ Annual savings;

= Melt KWH x Average cost/KWH* x Percent savings

= 9,701,109 x .0645 x .024 = 15,017/year

For graphic illustration of methodology used in calculating electrical savings, see Figures 1 and 2.

1/ Worksheet Table 4

2/ Worksheet Table 1

3/ Worksheet Table 2

2. Demand Limiting & Load Shifting

	Summer	Winter	Total
Normal Melting Cost	61,066	55,747	116,813
4/ Revised Melting Cost	52,536	45,187	97,723
Total			19,090

Percent savings = $\frac{19,090}{116,813}$ = 16.4%

Annual savings;

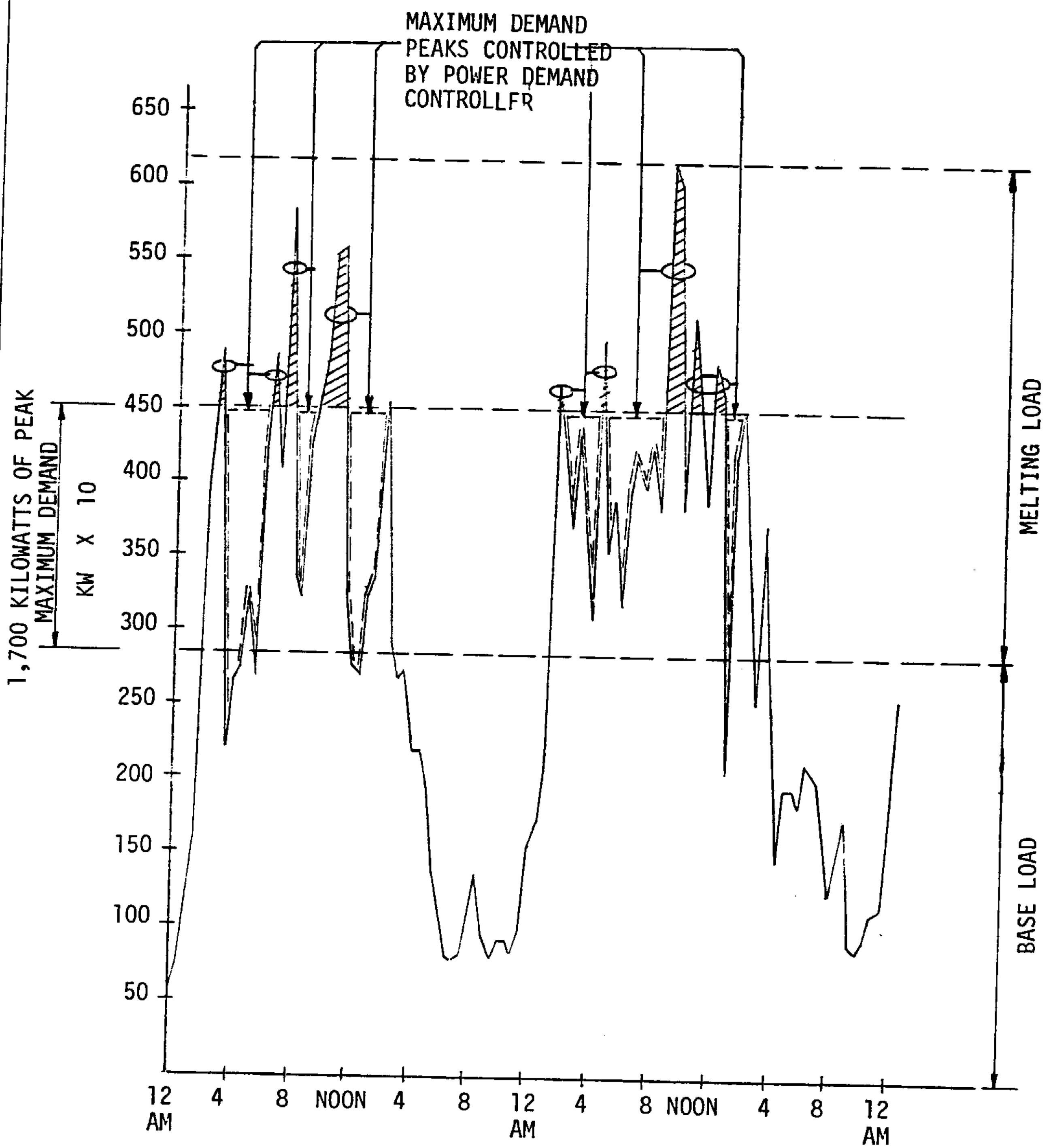
= Melt KWH x Average cost/KWH* x Percent savings

= 9,701,109 x .0645 x .164 = 102,618/year

For graphic illustration of methodology used in these calculations of electrical savings, see figures 3 and 4.

*Note - 1980 energy costs used

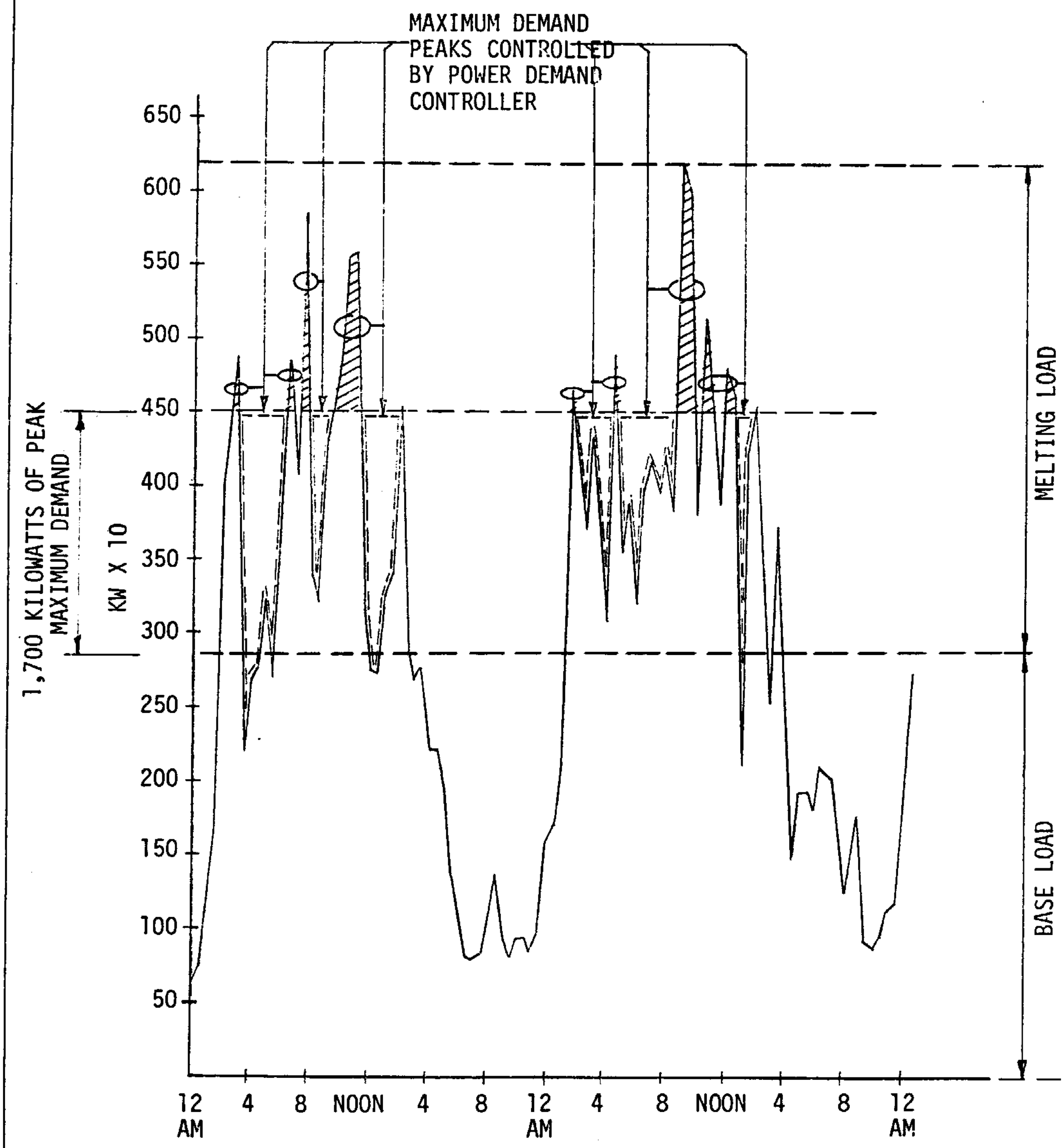
4/ Worksheet Table 3



SUMMER - "TIME OF DAY" BILLING

KILOWATT DEMAND PROFILE

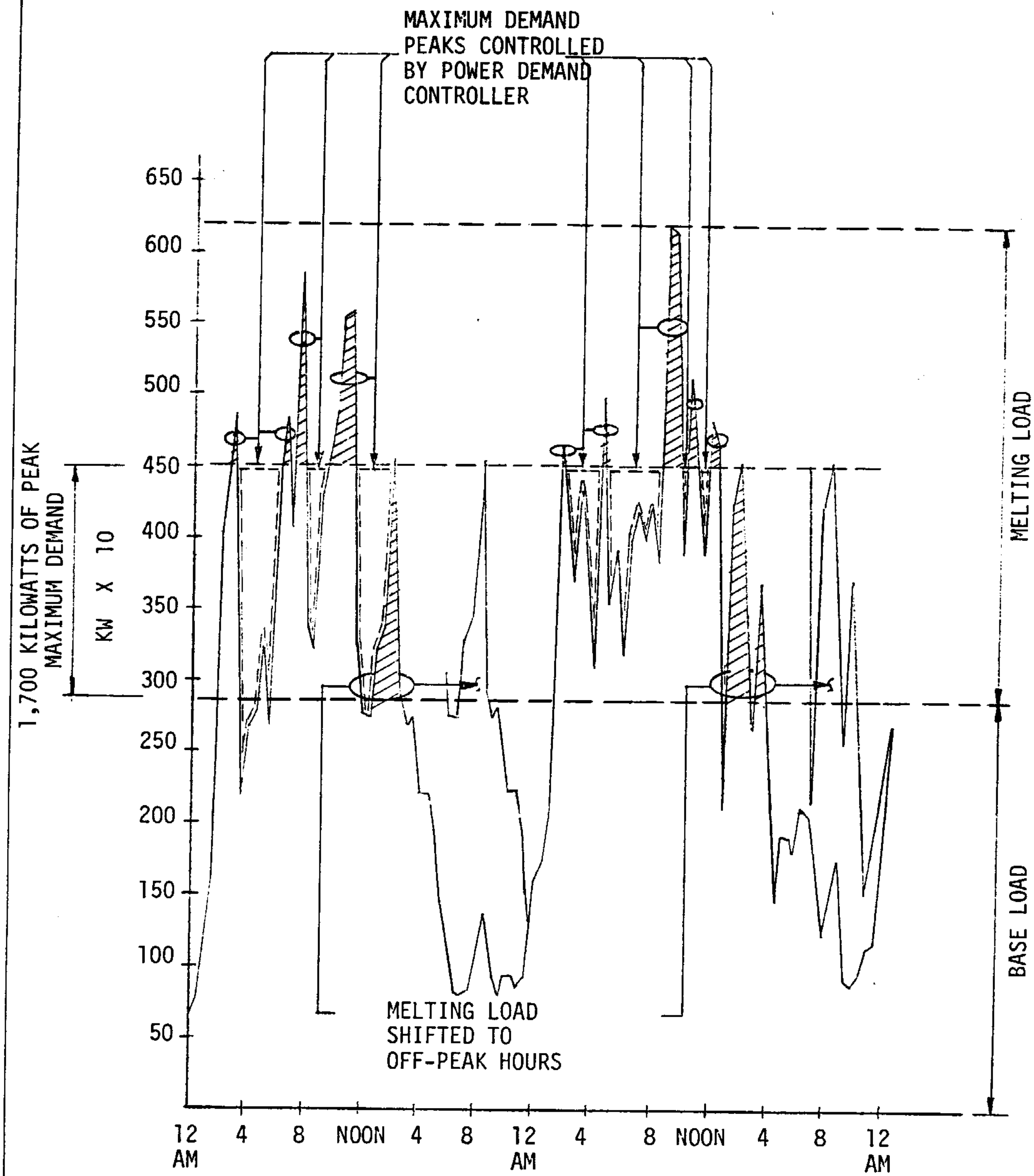
FIGURE 1
1 of 2



WINTER - "TIME OF DAY" BILLING

KILOWATT DEMAND PROFILE

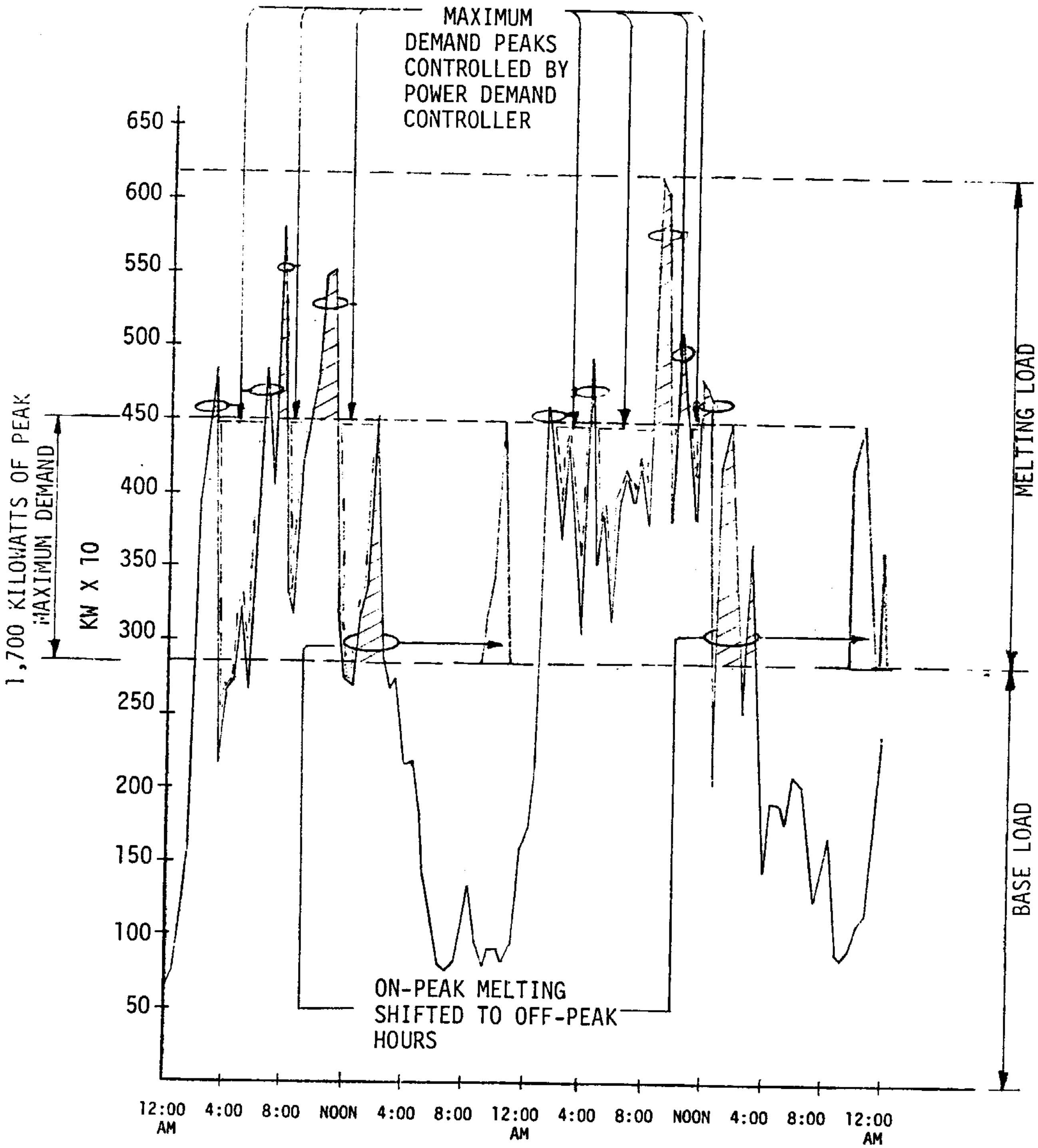
FIGURE 1
2 of 2



SUMMER - "TIME OF DAY" BILLING

KILOWATT DEMAND PROFILE

FIGURE 2
1 of 2



WINTER - "TIME OF DAY" BILLING

KILOWATT DEMAND PROFILE

FIGURE 2
2 of 2

NORMAL MELTING (SUMMER)

Demand Charges:

"On-peak" per kilowatt of maximum demand

Total on peak 1,457 kW at $5.050	$ 7,358
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 3,297 kW at $0.65	$ 2,143
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 3,727 kW no charge	$ 0
Subtotal	$ 9,501

Energy Charge:

"On-peak" per kilowatt hour:	
12:30 pm to 6:30 pm hrs/day	
Total kilowatt hours 90,050 x ¢ 0.0053/kwh	$ 477
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm	
and 6:30 pm to 10:30 pm .8 hrs/day	
Total kilowatt hours 461,164 x ¢ 0.0038/kwh	$ 1,752
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 423,809 x ¢ 0.0023/kwh	$ 975
Subtotal	$ 3,204

Fuel Adjustment Charges:

Total kilowatt hours = 975,024 x ¢ 0.0496	$ 48,361
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$ 61,066

TABLE 1

NORMAL MELTING (WINTER)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 1,778 kW at $5.050	$	8,979
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 3,748 kW at $0.65	$	2,436
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 3,593 kW no charge	$	0
Subtotal	$	11,515
Energy Charge:		
"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 98,969 x ¢0.0053/kwh	$	525
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 277,602 x ¢0.0038/kwh	$	1,055
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 461,940 x ¢0.0023	$	1,062
Subtotal	$	2,642
Fuel Adjustment Charges:		
Total kilowatt hours = 838,512 x ¢0.0496	$	41,590
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	55,747

TABLE 1

SHEET 2 of 2

DEMAND LIMITING (SUMMER)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 1,457 kW at $ 5.050	$	7,358
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,700 kW at $ 0.65	$	1,105
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,700 kW no charge	$	0
Subtotal	$	8,463
Energy Charge:		
"On-peak" per kilowatt hour:		
4:30 pm to 8:30 pm 4 hrs/day		
Total kilowatt hours 90,050 x ¢0.0053/kwh	$	477
"Partial peak" kilowatt hours:		
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day		
Total kilowatt hours 461,164 x ¢0.0038/kwh	$	1,752
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 423,809 x ¢0.0023/kwh	$	975
Subtotal	$	3,204
Fuel Adjustment Charges:		
Total kilowatt hours = 975,024 x ¢0.0496	$	48,361
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$	60,028

TABLE 2

SHEET 1 of 2

DEMAND LIMITING (WINTER)

Demand Charges:

"On-peak" per kilowatt of maximum demand	
Total on peak 1,700 kW at $5.050	$ 8,585
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 1,700 kW at $0.65	$ 1,105
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 1,700 kW no charge	$ 0
Subtotal	$ 9,690

Energy Charge:

"On-peak" per kilowatt hour:	
12:30 pm to 6:30 pm hrs/day	
Total kilowatt hours 98,969 x ¢0.0053/kwh	$ 525
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm	
and 6:30 pm to 10:30 pm .8 hrs/day	
Total kilowatt hours 277,602 x ¢0.0038/kwh	$ 1,055
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 461,940 x ¢0.0023/kwh	$ 1,062
Subtotal	$ 2,642

Fuel Adjustment Charges:

Total kilowatt hours = 838,512 x ¢0.0496	$ 41,590
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$ 53,926

TABLE 2

SHEET 2of 2

ON-PEAK MELTING SHIFTED TO PARTIAL AND OFF-PEAK WITH DEMAND LIMITING (SUMMER)

Demand Charges:		
"On-peak" per kilowatt of maximum demand		
Total on peak 0 kW at $ 5.050	$	0
Plus "partial peak" per kilowatt of maximum demand		
Total partial peak 1,700 kW at $ 0.65	$	1,105
Plus "off-peak" per kilowatt of maximum demand		
Total "off-peak" 1,700 kW no charge	$	0
Subtotal	$	1,105
Energy Charge:		
"On-peak" per kilowatt hour:		
12:30 pm to 6:30 pm hrs/day		
Total kilowatt hours 0 x ¢0.0053/kwh	$	0
"Partial peak" kilowatt hours: 8:30 am to 12:30 pm		
and 6:30 pm to 10:30 pm 8 hrs/day		
Total kilowatt hours 551,214 x ¢0.0038/kwh	$	2,095
"Off-peak" kilowatt hours:		
10:30 pm to 8:30 am 10 hrs/day		
Total kilowatt hours 423,809 x ¢0.0023/kwh	$	975
Subtotal	$	3,070
Fuel Adjustment Charges:		
Total kilowatt hours = 975,024 x ¢ 0.0496	$	48,361
GRAND TOTAL for (demand, energy and fuel adjustment charges	$	52,536

TABLE 3

SHEET 1 of 2

ON-PEAK MELTING SHIFTED TO PARTIAL AND OFF-PEAK WITH DEMAND LIMITING (WINTER)

Demand Charges:	
"On-peak" per kilowatt of maximum demand	
Total on peak 0 kW at $ 5.050	$ 0
Plus "partial peak" per kilowatt of maximum demand	
Total partial peak 1,700 kW at $ 0.65	$ 1,105
Plus "off-peak" per kilowatt of maximum demand	
Total "off-peak" 1,700 kW no charge	$ 0
Subtotal	$ 1,105
Energy Charge:	
"On-peak" per kilowatt hour:	
4:30 pm to 8:30 pm 4 hrs/day	
Total kilowatt hours 0 x ¢ 0.0053/kwh	$ 0
"Partial peak" kilowatt hours:	
8:30 am to 4:30 pm and 8:30 pm to 10:30 pm 10 hrs/day	
Total kilowatt hours 376,571 x ¢0.0038/kwh	$ 1,430
"Off-peak" kilowatt hours:	
10:30 pm to 8:30 am 10 hrs/day	
Total kilowatt hours 461,940 x ¢0.0023/kwh	$ 1,062
Subtotal	$ 2,492
Fuel Adjustment Charges:	
Total kilowatt hours = 838,512 x ¢0.0496	$ 41,590
GRAND TOTAL for (demand, energy and fuel adjustment charges)	$ 45,187

TABLE 3

Total Melting Energy (use actual metered consumption if available or estimate as follows)

$$\frac{\text{Annual tons shipped}}{\text{Overall Foundry yield \%}} = \text{Total tons melted/year}$$

Total tons melted x average KWH/ton = Total energy

Example:

$$\frac{\text{Annual tons shipped}}{\text{Foundry yield \%}} = \frac{9{,}600}{0.94} = 10{,}137$$

(a) Tons melted/yr. x KWH/ton* = 10,137 x 957

= 9,701,109

Percent melting energy of total electrical usage

$$\frac{\text{(a) KWH}}{\text{Total Electric Energy KWH}}$$

$$\frac{9{,}701{,}109}{18{,}127{,}200} = 54\%$$

Note: KWH/ton determined from actual melt cycle or use industry average for type of furnace and metal melted.

TABLE 4

UPGRADING HEAT TREAT FURNACES

Total plant gas consumption	=	709,170 therms/yr
Total annual gas cost	=	$ 186,877.00
Average gas cost	=	$ 0.26/therm

Due to the lack of adequate data relative to actual gas flow rates, the following assumptions have been made regarding gas energy distribution throughout the plant:

• Heat treat operations	40%
• Ladle heating operations	14%
• Spinner mold heaters	13%
• Mold ovens	13%
• Miscellaneous	20%
TOTAL	100%

Total estimated gas consumption attributed to heat treat furnace operations is approximately (709,170 x 0.4) = 283,668 therms/yr.

Substantial energy savings can be realized by upgrading the present heat treat furnaces in the following areas:

- Replace existing conventional firebrick linings with ceramic fiber insulation linings.
- Replace existing burners with high-efficiency burner systems and fuel/air ratio controls.

- Repair all cracks and install furnace pressure controls.
- Add recuperators for combustion air preheating.

If all of the above improvements are made, approximately 56% increase in overall furnace efficiency is possible.

Potential energy savings:

(283,668 therms x 0.56) = 158,854 therms/yr

Potential annual cost savings:

(158,854 x 0.26) = $ 41,303.00 per yr

UPGRADING LADLE HEATERS

Total estimated gas consumption attributed to ladle heating is approximately (709,170 therms x 0.14) = 99,283 therms/yr.

Substantial energy savings can be realized by upgrading the present ladle heaters in the following areas:

- Replace existing burners with high-efficiency burner system.
- Install ladle heater covers.

If the above improvements are made, approximately 50% increase in overall furnace efficiency is possible.

Potential energy savings:

(99,283 therms x 0.50) = 49,641 therms/yr

Potential cost savings:

(49,641 x 0.26) = $ 12,906.00 per yr

PART F

ECONOMIC ANALYSIS

PART F

ECONOMIC ANALYSIS

ELECTRICAL CONTROLS

Electrical controller costs for demand limiting in this facility are stated as order of magnitude to indicate method of calculation only.

UPGRADING HEAT TREAT FURNACES

Order of magnitude cost per installation of new ceramic linings, new gas burner systems, pressure controls and hot gas recuperation is estimated at approximately $400,000 for 10 heat treat furnaces.

Capital cost expenditure includes cost of materials and some outside labor. It has been assumed that the majority of the labor will be performed by in-house personnel and expensed.

Payback period based on $41,303 energy cost savings per year and $400,000 capital expense is:

$$\frac{\$400{,}000}{\$\ 41{,}303} = \underline{9.7 \text{ years}}$$

The following conditions will lower the anticipated payback period considerably:

- Present day equipment costs used, while the energy savings cost is based on 1979 calendar year average energy cost of $0.26 per therm.

- No credit taken for government tax break for installation of energy saving devices.
- Calculation of return on investment utilizing life-cycle costing methods, which take into account depreciation, cost of money and escalation of energy cost over the lifetime of the equipment, will possibly make the capital investment attractive.

UPGRADING LADLE HEATERS

Order of magnitude cost for installation of ladle heater covers and high-efficiency burners is estimated at $72,000 for 12 ladle heaters. Capital cost expenditure includes cost of materials and some outside labor. It has been assumed that the majority of the labor will be performed by in-house personnel and expensed.

Payback period based on $12,906 energy cost savings per year and $72,000 capital expense is:

$$\frac{\$72,000}{\$12,906} = \underline{5.57 \text{ years}}$$

The same qualifications for lowering the payback period, as mentioned for heat treat furnaces, also applies to ladle heating economics.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

(ALTERNATE 1)

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Demand controllers	—	$ 15,017	$ 200,000	13.3
Upgrading heat treat furnaces	15,885.4	41,300	400,000	9.7
Upgrading ladle heaters	4,964.1	12,900	72,000	5.6
TOTAL	20,849.5	$ 69,217	$ 672,000	9.7

TABLE 1

PART G

SUMMARY OF ENERGY REDUCTION

(ALTERNATE 2)

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Load shifting and demand controllers	-	$102,618	$ 200,000	1.94
Upgrading heat treat furnaces	15,885.4	41,300	400,000	9.7
Upgrading ladle heaters	4,964.1	12,900	72,000	5.6
TOTAL	20,849.5	$156,818	$ 672,000	4.28

TABLE 2

FOUNDRY "F"

PROJECTED ENERGY-EFFICIENCY RECORD

(ALTERNATE 1)

MONTH OR YEAR RECORDED		1979 /80
UNITS OF PRODUCTION		9,600 TONS SHIPPED
FUEL COSTS		
• Electricity	$	1,155,216 2/
• Natural Gas		132,700
• Propane		--
• Oil		--
• Coke		--
• Other		--
TOTAL	$	1,287,916

ENERGY USED

• KWH	18,127,200	x	3,412 Btu	=	61,850	Btu x 10^6
• Mcf Gas	49,347.5		--	1/	49,347.5	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	--	
• Gal. Oil		x	140,000 Btu	=	--	
• Coke - lb.		x	12,500 Btu	=	--	
•				=	--	
			TOTAL BTU		111,197.5	Bt7 x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{111,197.5}{9,600}$ = 11.58 Btu x 10^6/ton

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{\$1,287,916}{111,197.5}$ = $ 11.58 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{\$1,287,916}{9,600}$ = $ 134.15 Cost/ ton

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ 1980 Projector Electrical cost.

TABLE 3

FOUNDRY "F"

PROJECTED ENERGY-EFFICIENCY RECORD

(ALTERNATE 2)

MONTH OR YEAR RECORDED				1979/80	
UNITS OF PRODUCTION				9,600 TONS SHIPPED	
FUEL COSTS					
• Electricity			$	1,067,615 2/	
• Natural Gas				132,700	
• Propane				--	
• Oil				--	
• Coke				--	
• Other				--	
		TOTAL	$	1,200,315	
ENERGY USED					
• KWH	18,127,200	x 3,412 Btu	=	61,850	Btu x 10^6
• Mcf Gas	49,347.5	x --	1/	49,347.5	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=	--	
• Gal. Oil		x 140,000 Btu	=	--	
• Coke - lb.		x 12,500 Btu	=	--	
•			=	--	
		TOTAL BTU		111,197.5	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{111,197.5}{9,600} = 11.58 \text{ Btu} \times 10^6$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{\$1,200,315}{111,197.5} = \$\ 10.79 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{\$1,200,315}{9,600} = \$\ 125.03 \text{ Cost/Ton}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ 1980 Projector Electricity Cost.

TABLE 4

SECTION III

TABLE OF CONTENTS

FOUNDRY "G"

FOUNDRY "G"

PART "A"

General Description

Wide range of non-ferrous sand and permanent mold castings. Aluminum castings up to 1,000 pounds brass and bronze alloys up to 300 pounds. Operates one shift per day, four days per week.

Facilities

Building Area	14,800 square feet
Manning Total	30
Average Shipments Approx.	133 Tons/yr.
Annual Sales	$2,000,000

Melt Furnaces

Capacities: 1 - Elect. Induction 200 kw (900 lbs/hr)

6 - Gas Fired Crucibles 500 lbs. (2,000 lbs./hr.)

Equipment

1 Automatic molding machine

4 Semi-automatic molding machines

6 Squeezer molding machines

Overhead sand system with automatic shakeout and 25 HP sand muller.

2 Batch sand mixers

2 Shell core machines

1 Core blower

Cleaning room equipment and inspection tools.

Total HP 217.

FART "B"

ENERGY USE TABLES

FOUNDRY "G"

ELECTRICAL POWER USAGE

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
May 1979	35,460	330		1,118.06	(37.94)	1,254.00	2,372.06	2,334.12
June 1979	33,780	325.2		1,065.08	(36.14)	1,235.76	2,300.84	2,264.70
July 1979	30,240	323.4		963.94	(32.36)	1,228.92	2,192.86	2,160.50
August 1979	40,500	403.8		1,349.47	(43.34)	1,534.44	2,883.91	2,840.57
September 1979	39,720	329.4		1,323.47	(42.50)	1,251.72	2,575.19	2,532.69
October 1979	34,260	315.0		1,143.26	(36.66)	1,197.00	2,340.26	2,303.60
November 1979	36,780	321.6		1,288.74	(39.35)	1,222.08	2,510.82	2,471.47
December 1979	31,020	339.6		1,319.90	(33.19)	1,290.48	2,610.38	2,577.19
January 1980	23,880	318.6		1,016.09	(25.55)	1,210.68	2,226.77	2,201.22
February 1980	27,360	298.2		1,187.49	(29.28)	1,133.16	2,320.65	2,291.37
March 1980	38,160	377.0		1,859.55	(40.83)	1,242.60	3,102.15	3,061.32
April 1980	34,320	314.4		1,672.41	(36.72)	1,194.72	2,867.13	2,830.41
TOTALS	405,480			15,307.46	(433.86)	14,995.56	30,303.02	29,869.16

AVERAGE COST PER KWH = $\frac{\$29,869.16}{405,480}$ = \$0.073/kwh

TABLE 1

FOUNDRY "G"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
MARCH 1979	4,682	468.2	1,045.74
APRIL 1979	4,449	444.9	996.33
MAY 1979	4,571	457.1	1,063.05
JUNE 1979	4,356	435.6	1,109.55
JULY 1979	2,773	277.3	708.15
AUGUST 1979	2,190	219.0	560.32
SEPTEMBER 1979	2,647	264.7	668.93
OCTOBER 1979	2,749	274.9	728.48
NOVEMBER 1979	3,187	318.7	843.75
DECEMBER 1979	2,212	221.2	645.68
JANUARY 1980	2,369	236.9	712.72
FEBRUARY 1980	3,620	362.0	1,096.07
TOTALS	39,805	3,980.5	10,178.77

HEAT CONTENT OF GAS = 1,038 BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{10,178.77}{39,805}$ = \$ 0.256 PER THERM

TABLE 2

FOUNDRY "G"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KWH	SERVICE
FURNACES (5)	CRUCIBLE	500#	5	18	16		
MOLDING EQUIPMENT	ALL				11		
NO-BAKE MOLDING	DEPENDABLE	15,000#MAX					
SAND EQUIPMENT							
MULLER	SIMPSON	1,600#			25		
BATCH MULLER	CARVER	100#			3		
SAND SYSTEM W/SHAKEOUT	ST. LOUIS				26		
CLEANING ROOM							
BAND SAWS					15		
BELT SANDERS					16		
CUT-OFF WHEELS					12		
WHEELABRATOR					18		
AIR COMP.	1-R 300H.				75		
FURNACE	AJAX INDUCTION	900#				200	

TABLE 3

FOUNDRY "G"

DESCRIPTION AND FLOW RATES OF GAS FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS NO.	BURNERS TYPE	OPERATION HRS/DAY	OPERATION DAYS/MO	AVERAGE CFH	MAXIMUM CFH
500# FURNACE	CRUCIBLE	1	ASPIRATOR	5	18	829	1,000
500# FURNACE	CRUCIBLE	1	ASPIRATOR	5	18	829	1,000
500# FURNACE	CRUCIBLE	1	ASPIRATOR	5	18	829	1,000
500# FURNACE	CRUCIBLE	1	ASPIRATOR	5	18	829	1,000
500# FURNACE	CRUCIBLE	1	ASPIRATOR	5	18	829	1,000
LADLE TORCHES	PREHEAT	1	ATMOS.	1	18	200	200
LADLE TORCHES	PREHEAT	1	ATMOS.	1	18	200	200
TORCH	CORE DRYING	1	ATMOS.	10	18	50	100
SHELL CORE MACHINE	DEPENDABLE 100	1	ATMOS.	2	18	75	100
PERM. MOLD		8	ATMOS.	3	1	300	400
SHELL CORE MACHINE	DEPENDABLE 200	1	ATMOS. (MULTI)	2	18	150	200
CORE OVEN	DESPATCH	1	ATMOS. (MULTI)	8	18	300	400
TOTALS						5,420	6,600

TABLE 4

FOUNDRY "G"

1979/80 ENERGY - EFFICIENCY RECORD

MONTH OR YEAR RECORDED			1979 - 1980	
UNITS OF PRODUCTION			133 NET GOOD TONS/YR	
FUEL COSTS				
• Electricity		$	29,869.16	
• Natural Gas			10,178.77	
• Propane			NONE	
• Oil			"	
• Coke			"	
• Other			"	
	TOTAL		40,047.93	

ENERGY USED

• KWH 405,480	x 3,412 Btu	=	1383.4	Btu x 10^6
• Mcf Gas 3,980.5		1/	3980.5	Btu x 10^6
• Gal. Propane	x 91,600 Btu	=	N/A	
• Gal. Oil	x 140,000 Btu	=	N/A	
• Coke - lb.	x 12,500 Btu	=	N/A	
•		=		
	TOTAL BTU		5363.9 x 10^6 BTU	

OR

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{5364}{133}$ = 40.33

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{40,047.93}{5364}$ = 7.47 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{40,047.93}{133}$ = 301.11 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "G"

ENERGY - EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED				1980 Projected (Electrical only)	
UNITS OF PRODUCTION				133	
				NET GOOD TONS/YEAR	
FUEL COSTS					
• Electricity			$	40,334	
• Natural Gas				10,178.77	
• Propane				NONE	
• Oil				"	
• Coke				"	
• Other				"	
		TOTAL	$	50,513	
ENERGY USED					
• KWH 405,480	x	3,412 Btu	=	1383.4	Btu x 10^6
• Mcf Gas 3,980.5	x		1/	3980.5	Btu x 10^6
• Gal. Propane		91,600 Btu	=		
• Gal. Oil	x	140,000 Btu	=		
• Coke - lb.	x	12,500 Btu	=		
•			=		
		TOTAL BTU		5363.9	Btu x 10^6
ENERGY USED PER UNIT OF PRODUCTION					
(Million Btu) / (Units)	5364 / 133		=	40.33	
COST PER MILLION BTU					
(Energy Cost) / (Million Btu)	50513 / 5364		= $	9.41	Cost/Btu x 10^6
COST PER UNIT OF PRODUCTION					
(Total Cost) / (Units)	50513 / 133		= $	379.7	Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with "1980" billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of demand control.

3/ All other energy costs are 1979 rates.

TABLE 6

PART "C"

PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE G

CASTING METAL Brass & Aluminum

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	N/A	N/A	N/A	N/A
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER	25.8	11.1		
TOTALS	310.0	133.0		$2,000,000

AVERAGE MELT TONS/DAY = N/A

REPORTED % SCRAP N/A

REPORTED % MELT LOSS N/A

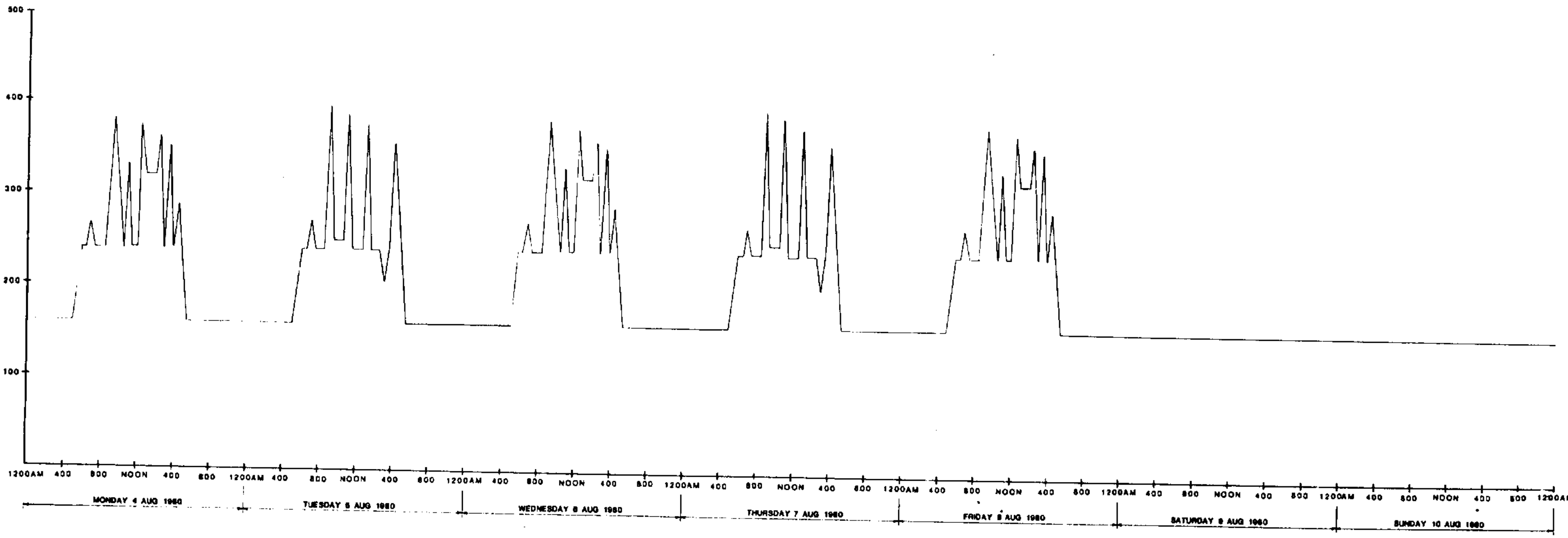
AVERAGE FOUNDRY YIELD % N/A

AVERAGE SALES VALUE/LB. N/A

TABLE 1

PART "D"

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE
INDUCTION FURNACES & GENERAL PLANT SERVICE

FOUNDRY G

FIGURE 1

OPERATIONAL DATA FACT SHEET

HIGH FREQUENCY INDUCTION MELTING

FURNACE MAKE AJAX MAGNETHERMIC MODEL NO. N/A

FURNACE SIZE N/A LBS

MELT TIME PER CYCLE N/A HRS.

MELTING RATE 900 LBS/HOUR

POURING TEMPERATURE 2200 °F - MELT PER DAY N/A

GENERATOR POWER RATING 200 KW 3000 CYCLES

MOTOR RATING N/A HP - MOTOR VOLTAGE N/A

COOLING WATER N/A TPM. TEMP IN N/A °F, TEMP OUT N/A °F

TYPE OF METAL MELTED BRONZE

REMARKS:

4.45 TONS PER MONTH MELTED (BRONZE)

TABLE 1

OPERATIONAL DATA FACT SHEETS

GAS FURNACE DATA

6 UNITS

Metal type: BRASS/ALUMINUM　Annual tons 75 TONS

Pouring or tap temperature 1400 °F

Heat content Btu/lb 500　Shifts/day 1

Melting period hrs. N/A　Holding period hrs. N/A

METHOD OF MELTING	CRUCIBLE	REVERB
Metal melted/hr.lbs.	100	NONE
Burner rating Btu/hr 1/		
Total gas usage/hr	N/A	
Capacity of furnace lbs.	500	
Crucible diameter	APPROX. 20"	
Area of metal radiation sq.ft.	N/A	
Area of refractory wall:		
Below metal	12 SQ. FT.	
Above metal	NONE	
Thickness of wall	6"	
Door open area or dip well sq.ft.	N/A	
Mean temperature of walls °F	N/A	
Outer temperature of walls T_1	N/A	
Inner temperature of walls T_2	N/A	
Present refractory K value	N/A	
Proposed refractory K value	N/A	
Rs value for refractory	N/A	
CO_2 flue gas reading	N/A	
Combustion air cfm	N/A	
Combustion air wg	N/A	
Flue gas (or comb.) temperature	N/A	
Ambient temperature °F	N/A	
Time of day used	N/A	
Days/year used	240	
Energy cost/therm $	0.756	

1/ BURNER RATING

4 UNITS RATES AT 2,000,000 BTU/HR
2 UNITS RATES AT 1,600,000 BTU/HR

TABLE 2

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

(2 UNITS)

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	N/A
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	NO	TYPE OF LINING	CONVENTIONAL F.B
INSIDE TEMP	N/A °F	OUTER SHELL TEMP	N/A °F
AMBIENT TEMP	VARIES °F		
GAS USAGE/HR	200 (EA) CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A °F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	NONE	RECUPERATOR EFFCY	NONE
FUEL COST/THERM	$ 0.256	ANNUAL USE	86 * BTU x 10^6
NUMBER OF UNITS IN USE	TWO		

* BASED ON 1 HOUR/DAY, 18 DAYS PER MONTH OPERATION

TABLE 3

PART E

ENERGY CONSERVATION POTENTIAL

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15- to 30-minute periods.

ELECTRICAL ENERGY COST SAVINGS

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Based on a sample billing period of one year, the cost reduction potential is:

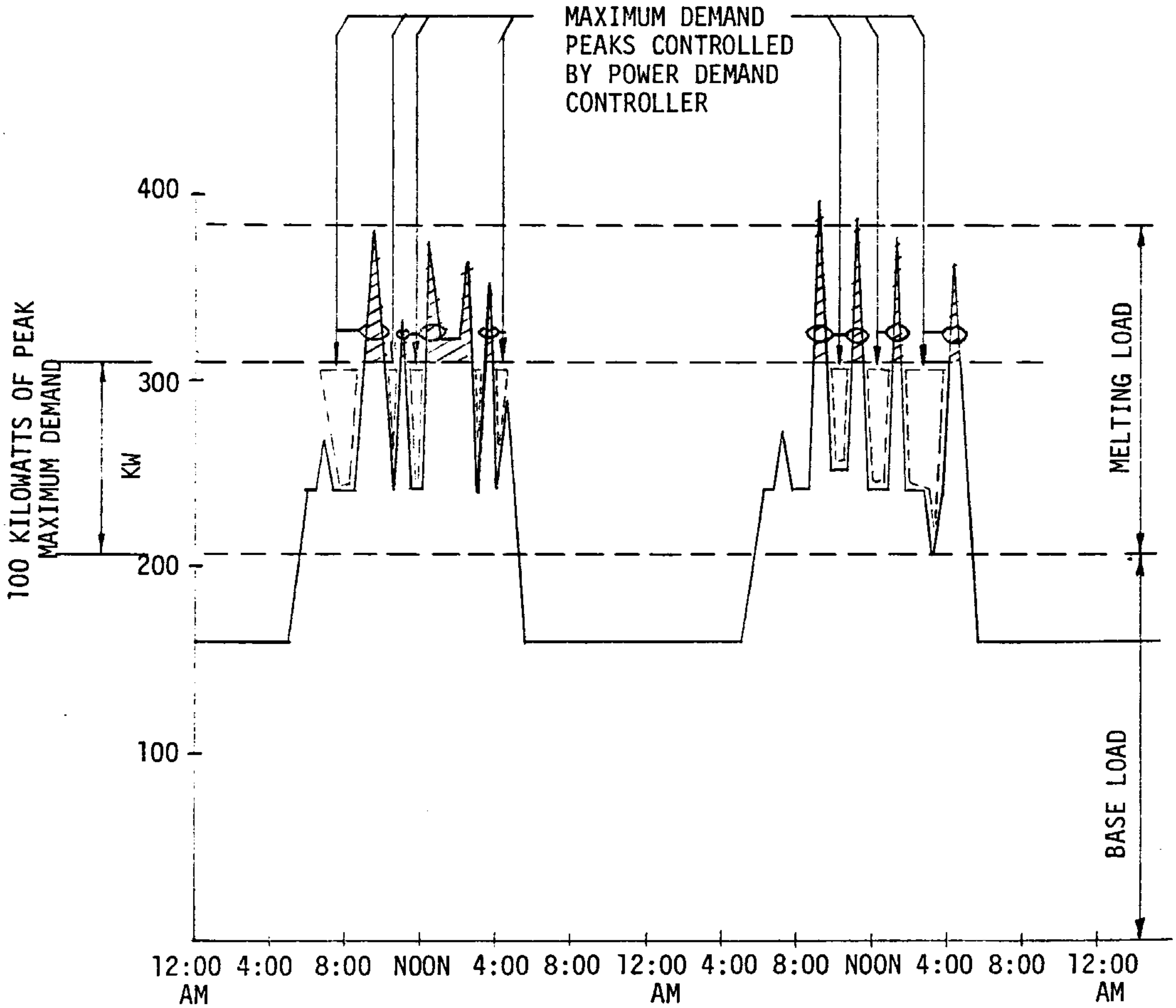
1. Demand Control

	Total
Normal melting demand cost[1/]	$5,686
Demand limited demand cost[1/]	$4,569
Annual Savings	$1117

$$\text{Percent savings} = \frac{\text{Reduction in cost}}{\text{Normal cost of melting}} = \frac{1117}{5686} = 19.6\%$$

For graphic illustration of methodology used in calculating electrical savings see Figures 1.

1/ See TABLE 1



KILOWATT DEMAND PROFILE

INDUSTRIAL ELECTRICAL RATE

FIGURE 1

DEMAND CONTROLLING

NORMAL MELTING COST			DEMAND CONTROLLING COST			
Month	Kilowatt Demand	Demand Charge	Kilowatt Demand	Demand Charge	Savings	%
Jan.	113	430.60	100	380.79	49.81	11.6
Feb.	124	472.19			91.40	19.4
March	119	453.99			73.20	16.12
April	125	476.52			95.73	20.1
May	124	458.19			77.40	16.9
June	123	466.98			86.19	18.5
July	154	583.08			202.29	34.7
Aug.	125	475.65			94.86	19.9
Sept.	120	454.86			74.07	16.3
Oct.	122	464.39			83.60	18.0
Nov.	129	490.38			109.59	22.3
Dec.	121	460.06			79.27	17.2
		5,686.89		4,569.48	1,117.41	19.65

Potential yearly saving (average) = 19.65%
Based on a maximum demand of 100 kw.

TABLE 1

TOTAL MELTING ENERGY (Use actual metered consumption if available or estimate as follows:)

$$\frac{\text{Annual tons shipped}}{\text{Overall Foundry yield \%}} = \text{Total tons melted per year}$$

Total tons melted X average kWh/ton = Total energy

Example:

$$\frac{\text{Annual tons shipped}}{\text{Foundry yield \%}} = \frac{133}{.43} = 310$$

Therefore, Tons melted/year X kWh/ton* = 310 x 500

= 155,000 KWH

Percent melting energy of total electrical usage

$$= \frac{\text{(a) kwh}}{\text{Total Elect. Energy kwh}} = \%$$

$$= \frac{155{,}000}{405{,}480} = 38\%$$

*Note: kWh/ton determined from actual melt cycle or use industry average for type of furnace and metal melted.

TABLE 2

UPGRADING GAS CRUCIBLE FURNACES

Total Annual Plant Gas Consumption	= 39,805 therms/yr
Total Annual Gas Cost	= $10,178.00 /yr
Average Cost of Gas	= $0.256/therm

Approximately 95% of total gas plant usage is consumed in the melting of metal. Therefore, gas usage attributed to this operation is: (39,805 therm/yr x 0.95) = 37,815 therms/year.

Substantial energy savings can be realized if the present gas fired crucible furnaces are upgraded in the following areas.

- Install high efficiency burner system and fuel/air ratio control system
- Install hot gas recuperator for combustion air pre-heating
- Install furnace covers
- Install ceramic fiber insulated lining

If the above improvements are made, it is possible to save approximately 51% of the gas input energy.

Potential energy savings	(37,815 x 0.51) =	19,286 therms/yr
Potential cost savings	(19,286 x 0.256) =	$4,937.00 /yr

UPGRADING LADLE HEATERS

Due to infrequent use of ladle heaters and the minor amount of energy usage, it would be impracticable to improve their efficiency.

PART F

ECONOMIC ANALYSIS

PART F

ECONOMIC ANALYSIS

Payback period is calculated as follows:

$$\frac{\text{Total capital investment}}{\text{Gross Energy cost reduction/year}} = \_\_\_\_\_\_ \text{years}$$

Payback years for individual projects are listed in Part "G" based on order of magnitude costs as follows:

• Demand Controller	$	4,000.00
• Upgrading Gas Crucibles	$	50,000.00
		60,000.00

The following conditions could lower the anticipation pay each period considerably:

- Present day equipment costs used (However the energy cost savings is based on 1979 calender year average energy cost, except for electricity costs, which is based on 1980 rates).

- No credit taken for government tax credit for installation of energy savings devices.

- Calculation of return on investment utilizies life cycle costing methods, which take into account depreliation, cost of money and excalation of energy test over the life time of the equipment, could possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Demand Controllers	---	1,117	$ 4,000	3.6 Yr's
Upgrading Gas Crucibles	1,928.6	4,937	$50,000	10.1 Yr's
TOTAL	1,928.6	6,054	$54,000	8.9%

TABLE 1

FOUNDRY "G"

PROJECTED ENERGY - EFFICIENCY RECORD

ALTERNATE - 1

MONTH OR YEAR RECORDED				April 1979 - March 1980	
UNITS OF PRODUCTION				133 NET GOOD TONS/YR	
FUEL COSTS					
• Electricity			$	39,217.00 2/	
• Natural Gas				6,241.77	
• Propane				N/A	
• Oil				N/A	
• Coke				N/A	
• Other				N/A	
		TOTAL	$	45,459.00	
ENERGY USED					
• KWH 405,480.00	x	3,412 Btu	=	1383.4	Btu x 10^6
• Mcf Gas 1976.8	x		1/	2051.9	
• Gal. Propane	x	91,600 Btu	=	N/A	
• Gal. Oil	x	140,000 Btu	=	N/A	
• Coke - lb.	x	12,500 Btu	=	N/A	
•			=		Btu x 10^6
		TOTAL BTU		3435.3	

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{3435}{133}$ = 25.82 Btu x 10^6/tow

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{45,459}{3435}$ = 13.23 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{45,459}{133}$ = 341.79 Cost/ Ton

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ Based on 1980 electric rate schedule.

TABLE 2

SECTION III

TABLE OF CONTENTS

FOUNDRY "H" Page

FOUNDRY "H"

PART A

GENERAL DESCRIPTION

A nonferrous foundry producing brass castings of average 18-pound weight. Green sand molding system of 6 TPH capacity supplies squeezer type machines. One 8-hour shift per day, 5 days per week, is worked.

FACILITIES

Building area	20,000 SF
Manning total	12 - 15
Shipments	87.4 tons/year
Sales value	$1,300,000/year
Foundry yield	50% net good compared to gross pour weight

MELTING FURNACES

Capacity

1 x 300 lb. electric induction (lift coil) 1,000 lbs/hr 180 kW rating.

1 x 3,000 lb. tilt furnace (used with above power unit).

1 x 100 lb. gas-fired alum crucible furnace.

EQUIPMENT

Green sand molding with squeezer machine is supplied with sand from overhead delivery system. Shell core requirements are purchased outside. Oil sand cores are produced by hand. Cleaning operations include abrasive and bandsaw cutoff and grinders.

PART B

ENERGY USE TABLES

FOUNDRY "H"

ELECTRICAL POWER USAGE TABLE (GENERAL PLANT SERVICE)

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	36,000	226		1,533.00	(34.00)	273.00	1,806.00	$ 1,772.00
FEBRUARY 1979	33,600	228		1,500.00	(35.00)	275.00	1,775.00	1,740.00
MARCH 1979	40,000	227		1,729.00	(35.00)	274.00	2,003.00	1,968.00
APRIL 1979	38,320	246		1,674.00	(37.00)	293.00	1,967.00	1,930.00
MAY 1979	38,720	254		1,698.00	(39.00)	301.00	1,999.00	1,960.00
JUNE 1979	42,880	266		1,851.00	(40.00)	313.00	2,164.00	2,124.00
JULY 1979	34,240	263		1,525.00	(40.00)	310.00	1,835.00	1,795.00
AUGUST 1979	48,880	265		2,046.00	(40.00)	317.00	2,363.00	2,323.00
SEPTEMBER 1979	31,600	274		1,422.00	(42.00)	321.00	1,743.00	1,701.00
OCTOBER 1979	28,400	280		1,285.00	(40.00)	307.00	1,592.00	1,552.00
NOVEMBER 1979	28,320	260		1,289.00	(40.00)	307.00	1,596.00	1,556.00
DECEMBER 1979	29,280	264		1,329.00	(40.00)	311.00	1,640.00	1,600.00
TOTALS	430,240			18,881.00	(462.00)	3,602.00	22,483.00	$22,021.00

Average Electrical Cost $= \frac{22021}{430240}$ \$0.051/kwh

TABLE 1

FOUNDRY H

ELECTRICAL POWER USAGE (LIGHTS, GENERAL OFFICE)

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT* CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	3,320	N/A	N/A	N/A	N/A	N/A		$ 179.79
FEBRUARY 1979	3,510	N/A	N/A	N/A	N/A	N/A		192.02
MARCH 1979	3,290	N/A	N/A	N/A	N/A	N/A		183.58
APRIL 1979	3,490	N/A	N/A	N/A	N/A	N/A		191.25
MAY 1979	3,770	N/A	N/A	N/A	N/A	N/A		202.00
JUNE 1979	3,790	N/A	N/A	N/A	N/A	N/A		202.70
JULY 1979	3,770	N/A	N/A	N/A	N/A	N/A		202.00
AUGUST 1979	4,150	N/A	N/A	N/A	N/A	N/A		217.47
SEPTEMBER 1979	4,150	N/A	N/A	N/A	N/A	N/A		216.58
OCTOBER 1979	3,650	N/A	N/A	N/A	N/A	N/A		197.58
NOVEMBER 1979	3,120	N/A	N/A	N/A	N/A	N/A		177.21
DECEMBER 1979	3,490	N/A	N/A	N/A	N/A	N/A		191.42
TOTALS	43,500							$2,353.60

COST SUMMARY (ALL SERVICES)

SERVICE	KWH	COST
LIGHTS, GENERAL OFFICE	43,500	$ 2,353.60
GENERAL PLANT SERVICES	430,240	22,021.00
TOTALS	473,740	$ 24,374.6

AVERAGE COST PER KWH $= \frac{24,374.6}{473,740} =$ $ 0.051

TABLE 1

FOUNDRY "H"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
JANUARY 1979	610	61.0	$ 144.00
FEBRUARY 1979	597	59.7	143.00
MARCH 1979	412	41.2	101.00
APRIL 1979	525	52.5	127.00
MAY 1979	315	31.5	82.00
JUNE 1979	332	33.2	94.00
JULY 1979	325	32.5	92.00
AUGUST 1979	292	29.2	84.00
SEPTEMBER 1979	279	27.9	82.00
OCTOBER 1979	266	26.6	80.00
NOVEMBER 1979	315	31.5	93.00
DECEMBER 1979	366	36.6	115.00
TOTALS	4,634	463.4	$ 1,237.00

HEAT CONTENT OF GAS = N/A. BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{1,237}{4,634}$ = $ 0.266 PER THERM

TABLE 2

FOUNDRY "H"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	SERVICE
FURNACE	INDUCTION	1,000#				180	
BAGHOUSE					30		
REMAINING PLANT LOADS					N/A		

TABLE 3

FOUNDRY "H"

DESCRIPTION AND FLOW RATES OF GAS-FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
CORE OVEN	5'x4'x5'	1	ATMOS. TUBULAR	8	22	70	100
CRUCIBLE	PIT (250#)	1	PREMIX	4	2	50	750
LADLE HEATER		1	ATMOS.	8	22	25	50
SPACE HEATER		1	ATMOS.			25	50
TOTALS						170	950

TABLE 4

FOUNDRY "H"

1979 ENERGY - EFFICIENCY RECORD

MONTH OR YEAR RECORDED		1979
UNITS OF PRODUCTION		87 NET GOOD TONS/YEAR
FUEL COSTS		
• Electricity	$	24,374.00
• Natural Gas		1,237.00
• Propane		--
• Oil		--
• Coke		--
• Other		--
TOTAL	$	25,611.00

ENERGY USED

• KWH	473,740	x	3,412 Btu	=	1,616.4	Btu x 10^6
• Mcf Gas	463.4			1/	463.4	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	--	
• Gal. Oil		x	140,000 Btu	=	--	
• Coke - lb.		x	12,500 Btu	=	--	
•				=	--	
			TOTAL BTU		2,079.8	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{2,079.8}{87 \text{ tons}}$ = $ 23.9 Btu x 10^6 Btu/ton

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{25,611}{2,079.8}$ = $ 12.31 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{25,611}{87}$ = $ 294.37 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "H"

ENERGY-EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED	1980 Projected (Electric only)
UNITS OF PRODUCTION	87 Net good tons per year
FUEL COSTS	
• Electricity	$ 29,806 2/
• Natural Gas	1,237.00
• Propane	None
• Oil	None
• Coke	None
• Other	None
TOTAL	$ 31,043

ENERGY USED

• KWH	473,740	x	3,412 Btu	=	1,616.4	Btu x 10^6
• Mcf Gas		x		1/	463.4	Btu x 10^6
• Gal. Propane		x	91,600 Btu	=	None	
• Gal. Oil		x	140,000 Btu	=	None	
• Coke - lb.		x	12,500 Btu	=	None	
•				=	None	
			TOTAL BTU		2,079.8	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}}{\text{(Units)}} \quad \frac{2,079.8}{87} = 23.9 \text{ Btu} \times 10^6\text{/Ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}} \quad \frac{31,043}{2,079.8} = \$\ 14.9 \quad \text{Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}}{\text{(Units)}} \quad \frac{31,043}{87} = \$\ 356.8 \quad \text{Cost/Ton}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with 1980 billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of demand control.

3/ All other energy costs are 1979 rates.

TABLE 6

PART C

PRODUCTION STATISTICS

PART C

ANNUAL PRODUCTION

FOUNDRY CODE H

CASTING METAL Brass

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	N/A	N/A	N/A	N/A
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
TOTALS	175.0	87.4		$1,300,000

AVERAGE MELT TONS/DAY = N/A

REPORTED % SCRAP N/A

REPORTED % MELT LOSS N/A

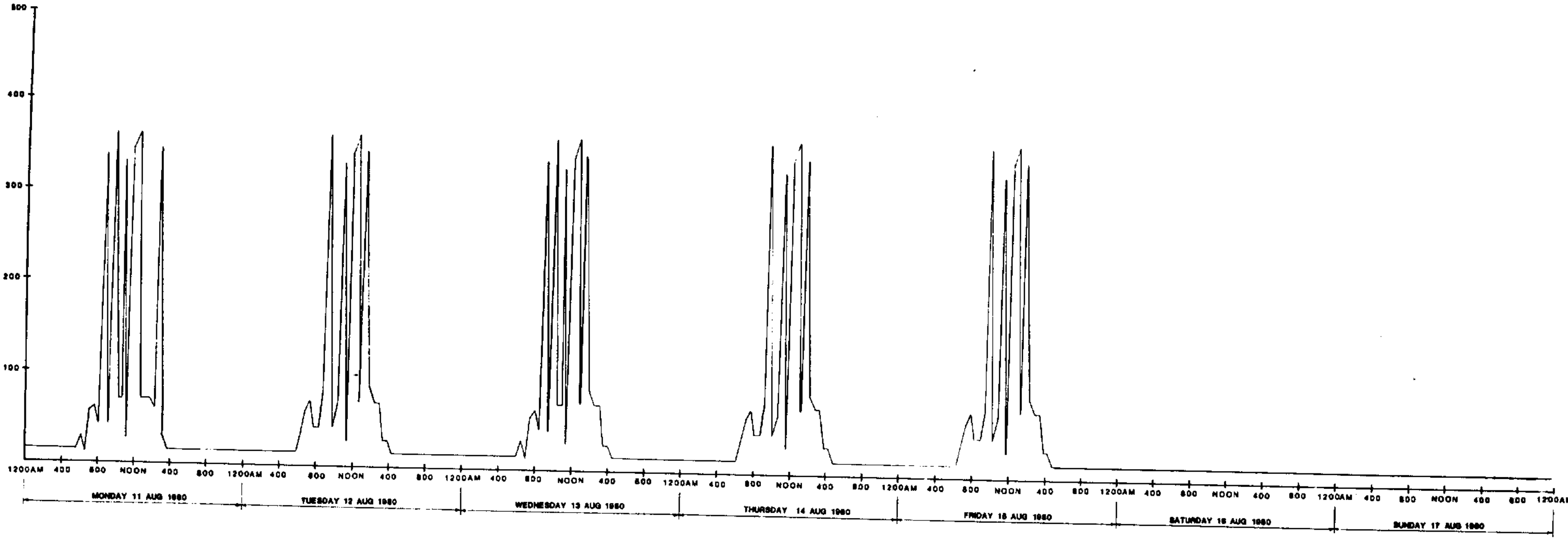
AVERAGE FOUNDRY YIELD % 50.0

AVERAGE SALES VALUE/LB. $7.43

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE
INDUCTION FURNACES & GENERAL PLANT SERVICE

FOUNDRY H

FIGURE 1

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

LADLE CAP TONS	0.02	HEAT CYCLES/DAY	1
LADLE AREA INSIDE	6 SQ FT.	LINING THICKNESS	2"
COVERED	NO	TYPE OF LINING	N/A
INSIDE TEMP	1,500 ^{o}F	OUTER SHELL TEMP	N/A ^{o}F
AMBIENT TEMP	^{o}F		
GAS USAGE/HR	25 CU FT.	CO_2 READING	
COMBUSTION AIR	None CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A ^{o}F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	None	RECUPERATOR EFFCY	None
FUEL COST/THERM	$ 0.266	ANNUAL USE	6.6 BTU x 10^6
NUMBER OF UNITS IN USE			

TABLE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

Furnace make ____N/A____ Transformer KVA ____180 kW____

Model ____Lift Coil____ Primary Voltage ____N/A____

Capacity ____300/1,300 lb.____ Secondary Voltage ____N/A____

Output ________ tons/yr.

________ tons/day

Alloy ____Brass____

Melt cycle ________ minutes

Tap Quantity ________ lbs.

Charge Quantity ________ lbs.

Tap temperature ________ ^{o}F

Holding temperature ____2,200____ ^{o}F

Slag cycle ________ minutes

Fume collection ________ CFM

Water cooling....GPM, Temp.........in ^{o}F.......Out ^{o}F

Type of Refractory ________

Energy consumption ____254,000____ KWH/YR

Energy Cost ____5.1____ ₵/KW

TABLE 2

PART E

ENERGY CONSERVATION POTENTIAL

PART E

ENERGY CONSERVATION POTENTIAL

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15- to 30-minute periods.

ELECTRICAL ENERGY COST SAVINGS

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following work sheets.

Based on a sample billing period of one year. The cost reduction potential is:

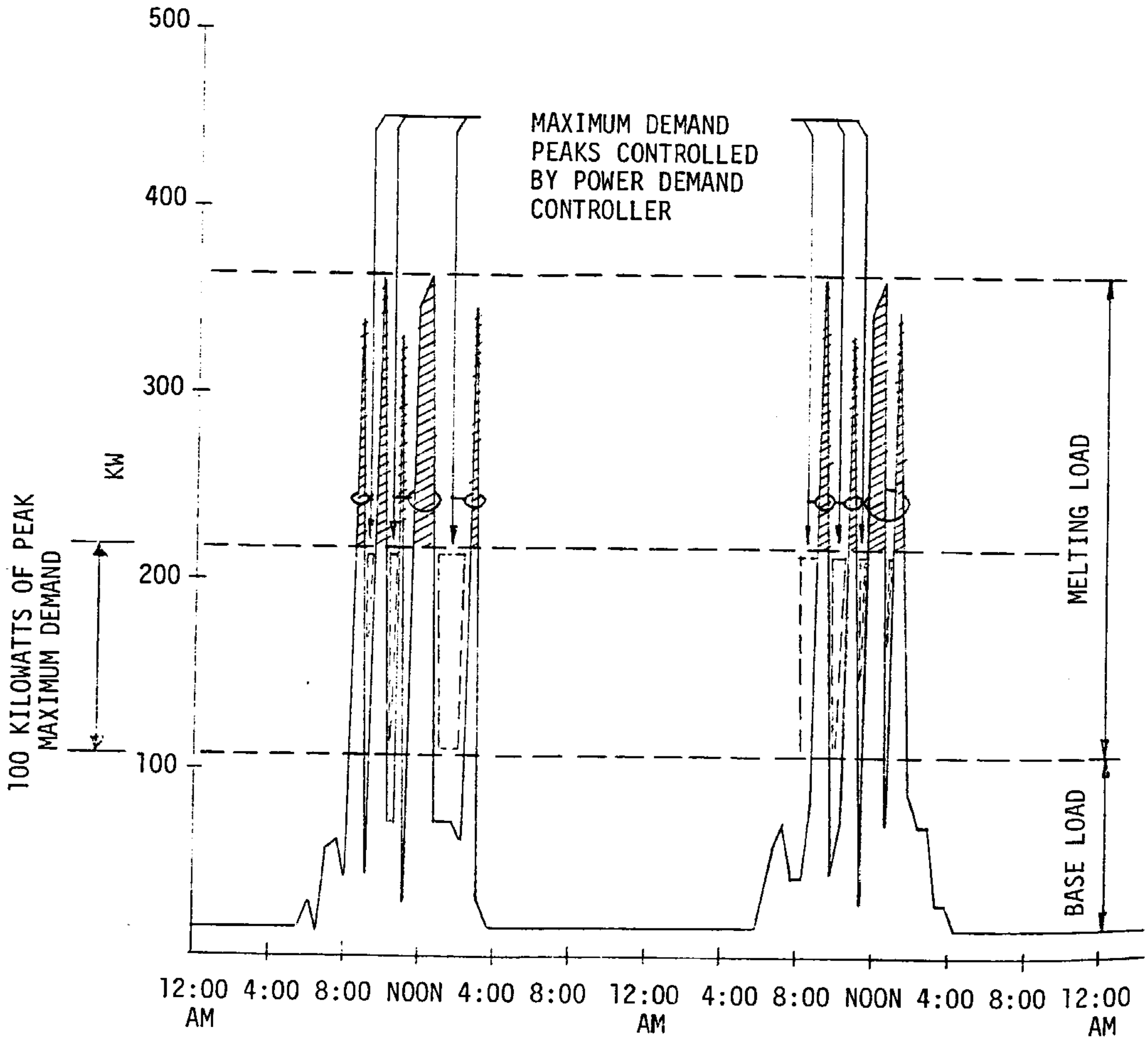
1. Demand Control

	Total
Normal melting demand cost 1/	$7,221
Demand limited demand cost 1/	5,160
Annual Savings	$2,061/yr

$$\text{Percent savings} = \frac{\text{reduction in cost}}{\text{normal demand cost of melting}} = \frac{2,061}{7,221} = 28.5\%$$

For graphic illustration of methodology used in calculating electrical savings see Figure 1.

1/ Work sheet Table 1 and 2.



KILOWATT DEMAND PROFILE

INDUSTRIAL ELECTRICAL RATE

FIGURE 1

DEMAND CONTROLLING

NORMAL MELTING COST			DEMAND CONTROLLING COST			
Month	Kilowatt Demand	Demand Charge	Kilowatt Demand	Demand Charge	Savings	%
Jan.	124	$533.30	100	430.08	$103.22	19.4
Feb.	125	537.60			107.52	20.0
March	125	537.60			107.52	20.0
April	135	580.62			150.54	25.9
May	140	602.12			172.04	28.6
June	146	627.93			197.85	31.5
July	145	623.63			193.55	31.0
Aug.	146	627.93			197.85	31.5
Sept.	151	649.43			219.35	33.8
Oct.	154	662.33			232.25	35.0
Nov.	143	615.03			184.95	30.0
Dec.	145	623.63			193.55	31.0
		$7,221.15		5,160.96	$2,060.19	

Potential yearly savings (average) = 28.5%
Based on a maximum demand of 100 kw.

TABLE 1

TOTAL MELTING ENERGY (Use actual metered consumption if available or estimate as follows:)

$$\frac{\text{Annual tons shipped}}{\text{Overall Foundry yield \%}} = \text{Total tons melted per year}$$

Total tons melted X average kWh/ton = Total energy

Example:

$$\frac{\text{Annual tons shipped}}{\text{Foundry yield \%}} = \frac{87.4}{.5} = 175$$

Therefore, Tons melted/year X kWh/ton* = 175 x 1,500

= 262,500 KWH

Percent melting energy of total electrical usage

$$= \frac{\text{(a) kwh}}{\text{Total Elect. Energy kwh}} = \%$$

$$\frac{262,500}{473,740} = 55\%$$

*Note: kWh/ton determined from actual melt cycle or use industry average for type of furnace and metal melted.

TABLE 2

Upgrading Ladle Preheater

The following approximate savings can be realized by improvements to:

Burner efficiency

Insulation added to Lining

Cover added

If the above improvements are made approx 50% reduction in gas usage is possible.

$$\text{Potential savings} = 6.6 \times 10^6 \times 0.5$$
$$= 3.3 \times 10^6 \text{ BTU/year}$$

@ $0.266 per therm, cost savings

$$= \frac{3.3 \times 10^6}{100{,}000} \times 0.266 = \$9$$

In view of the minor savings for this size of equipment, the chagnes are not viable.

PART F

ECONOMIC ANALYSIS

ECONOMIC ANALYSIS

The calculation of payback period is as follows:

$$\frac{\text{Capital Investment}}{\text{Energy Cost Savings/Year}} = \text{years}$$

In this foundry, the economic savings are obtained by control of electric load demand as summarized in Section G.

Equipment costs are estimated to be $4,000.

The following conditions could lower the anticipated payback period considerably:

- Present day equipment costs used. However, the energy cost savings is based on 1979 calendar year average energy cost except for electricity cost, which is based on 1980 billing rates.
- No credit taken for government tax credit for installation of energy-saving devices.
- Calculation of return on investment utilizing life-cycle costing methods, which take into account depreciation, cost of money and escalation of energy cost over the lifetime of the equipment, could possibly make the capital investment attractive.

PART G

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS $	CAPITAL INVESTMENT	PAYBACK PERIOD YEAR
Demand Controllers	--	$2,060	$4,000	1.9
TOTAL	--	$2,060	$4,000	1.9

TABLE 1

FOUNDRY "H"

PROJECTED ENERGY EFFICIENCY RECORD

MONTH OR YEAR RECORDED				1980
UNITS OF PRODUCTION				87.4 Tons
FUEL COSTS				
• Electricity				$ 27,745 2/
• Natural Gas				1,237
• Propane				
• Oil				
• Coke				
• Other				
		TOTAL		28,982
ENERGY USED				
• KWH	473,740	x 3,412 Btu	=	1,616.4 Btu x 10^6
• Mcf Gas	463.4	--	1/	463.4 Btu x 10^6
• Gal. Propane		x 91,600 Btu	=	
• Gal. Oil		x 140,000 Btu	=	
• Coke - lb.		x 12,500 Btu	=	
•			=	
		TOTAL BTU		2,079.8 Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}\ 2{,}079.8}{\text{(Units)}\ 87.4} = 23.9 \times 10^6 \text{ Btu/ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}\ \$24{,}837}{\text{(Million Btu)}\ 2{,}079.8} = 13.93 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}\ \$28{,}982}{\text{(Units)}\ 87.4} = 331.6 \text{ Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ 1980 projected electrical costs.

TABLE 2

SECTION III

TABLE OF CONTENTS

FOUNDRY "I"

PART A

GENERAL DESCRIPTION

Foundry produces a range of sand casting in red brass, yellow brass 70 mag. brass, Navy M and Navy C brass. Aluminum alloys 356 and tensalloy on 1 shift, four days per week.

FACILITIES

Building area	N/A
Manning total	40
Annual Shipments	780 tons
Annual Sales	$5.0 million

MELT FURNACES

Capacities:

1 Electric Furnace	1000lbs
4 Gas furnaces	800lbs (Ave. 1.5 hrs. cycle)

EQUIPMENT

5 squeezer molding units, 2 cope and drag type molding machines are supplied with sand from a 25 HP sand muller with delivery system. Core making is shell and oil sand. Cleaning room facilities includes blast cabinet, cut-off jaws and grinders. Compressed air is supplied by 2 units having a total 75 HP capacity.

PART B

ENERGY USE TABLES

FOUNDRY "I"

ELECTRICAL POWER USAGE TABLE

BILLING PERIOD	ENERGY KWH	BILLING DEMAND	POWER FACTOR	ENERGY CHARGE	FUEL ADJUSTMENT CHARGE	DEMAND CHARGE	GROSS BILL	NET BILL
JANUARY 1979	26,640	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FEBRUARY 1979	36,000							
MARCH 1[illegible]	[illegible],9[illegible]							
APRIL 1979	56,4[illegible]							
MAY [illegible]79	[illegible]5,761							
JUNE 1979	62,16[illegible]							
JULY 1979	59,520							
AUGUST 1[illegible]79	65,520							
SEPTEMBER 1979	55,680							
OCTOBER 1979	66,240							
NOVEMBER 1979	31,440							
DECEMBER 1979	24,480							
TOTALS	605,761							$38,113[1/]

1/ Average electricity cost = $\frac{38,113}{605.761}$ = $0.062/KWH

TABLE 1

FOUNDRY "I"

ANNUAL GAS CONSUMPTION

PERIOD	THERMS	BTU X 10^6	COST
Jan. 1979	11,817	1,181	N/A
Feb. 1979	12,282	1,228	
Mar. 1979	10,110	1,011	
Apr. 1979	10,371	1,037	
May 1979	10,818	1,081	
June 1979	11,146	1,114	
July 1979	9,584	958	
Aug. 1979	9,480	948	
Sept. 1979	9,170	917	
Oct. 1979	9,126	912	
Nov. 1979	8,932	893	
Dec. 1979	9,362	936	
TOTALS	122,198	12,219	$29,429[1/]

HEAT CONTENT OF GAS = N/A BTU/CU FT (FROM BILL)

100,000 BTU = 1 THERM

COST OF GAS = $\frac{29,429}{122,198}$ = 0.240 PER THERM

TABLE 2

FOUNDRY "I"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	SERVICE
MELT FURNACE #1	GAS (ALUMIMUM)	250#			1		
MELT FURNACE #2	GAS (BRASS)	800#			3		
MELT FURNACE #3	GAS (BRASS)	800#			3		
MELT FURNACE #4	GAS (BRASS)	800#			3		
MELT FURNACE #5	ELECTRIC INDUCTION	1,000#				210	
HYDRAULIC FURNACE PUMP					8		
LADLE		300#			1-1/2		
HAWLEY UNIT					1		
MULLER					25		
BUCKET ELEVATOR					10		
SAND SCREEN					5		
AIR COMPRESSOR	GARDNER DENVAR				25		
AIR COMPRESSOR	WORTHINGTON				50		
BLAST CABINET					26		
DUST COLLECTOR					7-1/2		
TABOR SAW					10		
BAND SAWS					6		
GRINDER					9		
BOLT GRINDER					7-1/2		
LARGE DUST COLLECTOR					40		

TABLE 3

FOUNDRY "I"

DESCRIPTION AND POWER USAGE OF ELECTRICAL EQUIPMENT

EQUIPMENT	TYPE	CAPACITY	OPERATION HRS/DAY	OPERATION DAYS/MO	H.P.	KW	SERVICE
MISCELLANEOUS					40		
TOTAL					281	210	

TABLE 3

FOUNDRY "I"

DESCRIPTION AND FLOW RATES OF GAS-FIRED EQUIPMENT

EQUIPMENT	TYPE	BURNERS		OPERATION		AVERAGE CFH	MAXIMUM CFH
		NO.	TYPE	HRS/DAY	DAYS/MO		
FURNACES (3)	CRUCIBLE	3	PREMIX	11	22	2,076	4,800
FURNACES (2)	CRUCIBLE	2	PREMIX	16	22	433	1,000
LADLE HEATERS (2)		2	H.P. ATMOS	16	22	216	500
CORE OVEN		1	MULTI-ATMOS	16	22	173	400
PIT FURNACE		1	PREMIX	16	22	216	500
SMALL CORE MACHINES (4)		32	ATMOS	16	22	346	800
SPACE HEATERS (2)		2	ATMOS	8	22	200	200
WATER HEATERS		1	ATMOS			40	40
TOTALS						3,700	8,240

TABLE 4

FOUNDRY "I"

1979 ENERGY-EFFICIENCY RECORD

MONTH OR YEAR RECORDED				1979	
UNITS OF PRODUCTION				780	
FUEL COSTS				Net good tons shipped	
• Electricity			$	38,113	
• Natural Gas				29,429	
• Propane				--	
• Oil				--	
• Coke				--	
• Other				--	
		TOTAL	$	67,540	
ENERGY USED					
• KWH 605,761	x	3,412 Btu	=	2,066	Btu x 10^6
• Mcf Gas 12,219	x		1/	12,219	
• Gal. Propane --	x	91,600 Btu	=	--	
• Gal. Oil --	x	140,000 Btu	=	--	
• Coke - lb. --	x	12,500 Btu	=	--	
•			=		
		TOTAL BTU		14,285	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)} \quad 14{,}285}{\text{(Units)} \quad 780 \text{ tons}} = 18.3 \quad 10^6 \text{ Btu per ton}$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)} \quad 67{,}540}{\text{(Million Btu)} \quad 14{,}285} = 4.72 \quad \text{Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)} \quad 67{,}540}{\text{(Units)} \quad 780 \text{ tons}} = 86.58 \quad \text{Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

TABLE 5

FOUNDRY "I"

ENERGY-EFFICIENCY RECORD 2/ 3/

MONTH OR YEAR RECORDED				1980 Projected (Electricity Only)
UNITS OF PRODUCTION				780 Net good tons per year
FUEL COSTS				
• Electricity			$	42,893
• Natural Gas				29,429
• Propane				NONE
• Oil				NONE
• Coke				NONE
• Other				NONE
		TOTAL	$	72,322

ENERGY USED

• KWH	605,761	x 3,412 Btu	=	2,066	Btu x 10^6
• Mcf Gas	12,219		1/	12,219	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=		
• Gal. Oil		x 140,000 Btu	=		
• Coke - lb.		x 12,500 Btu	=		
•			=		
		TOTAL BTU		14,285	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$\frac{\text{(Million Btu)}}{\text{(Units)}}$ $\frac{14,285}{780}$ = 18.3 Btu x 10^6/ton

COST PER MILLION BTU

$\frac{\text{(Energy Cost)}}{\text{(Million Btu)}}$ $\frac{72,322}{14,285}$ = $ 5.06 Cost/Btu x 10^6

COST PER UNIT OF PRODUCTION

$\frac{\text{(Total Cost)}}{\text{(Units)}}$ $\frac{72,322}{780}$ = $ 92.72 Cost/Unit

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ The electrical cost shown represents 1980 calendar year costs and are based on 1979 energy consumption with 1980 billing rates applied. The projected electrical cost is used as a base for calculating cost savings by implementation of demand control.

3/ All other energy costs are 1979 rates.

TABLE 6

PART C

PRODUCTION STATISTICS

ANNUAL PRODUCTION

FOUNDRY CODE I

CASTING METAL Brass & Aluminum

PERIOD	MELT TONS	SHIPPED TONS	HEAT TREAT TONS	SALES VALUE
JANUARY	128.4	62.6	N/A	N/A
FEBRUARY	120.2	58.6		
MARCH	156.7	76.4		
APRIL	132.5	64.6		
MAY	163.3	79.6		
JUNE	135.4	66.0		
JULY	138.5	67.5		
AUGUST	148.7	72.5		
SEPTEMBER	128.4	62.6		
OCTOBER	140.7	68.6		
NOVEMBER	100.5	49.0		
DECEMBER	106.7	52.0		
TOTALS	1,600.0	780.0		$5,000,000

AVERAGE MELT TONS/DAY = 7.5

REPORTED % SCRAP 10.0

REPORTED % MELT LOSS 10.0

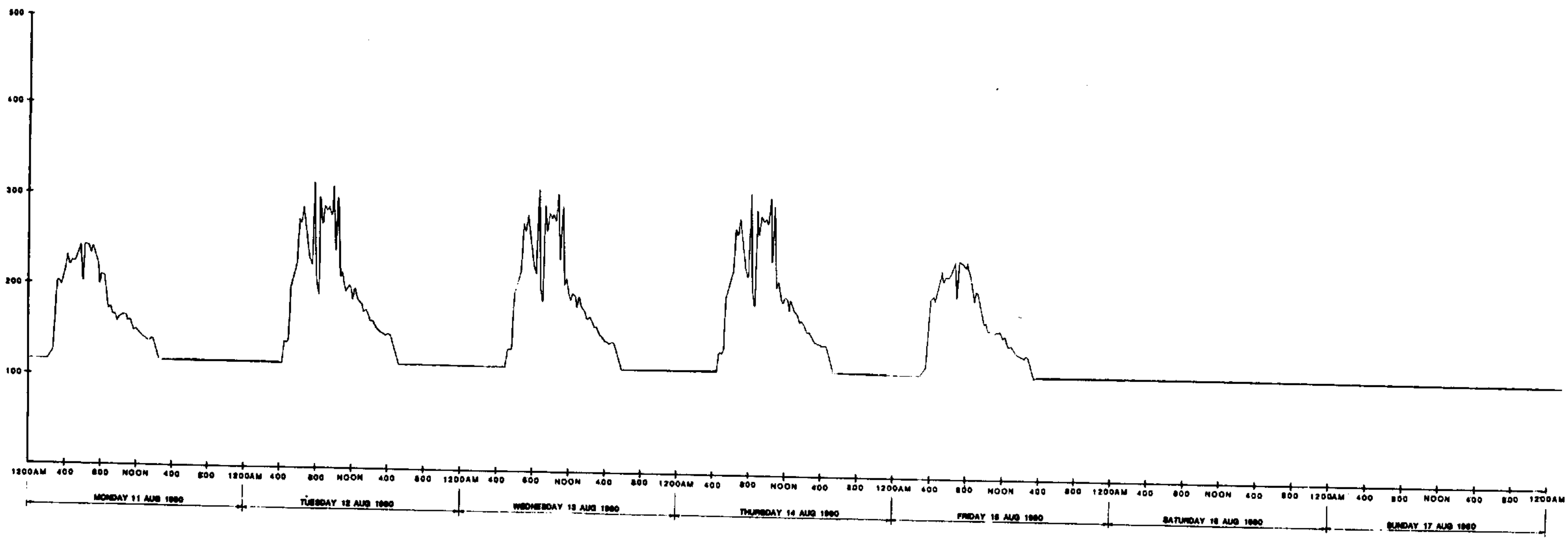
AVERAGE FOUNDRY YIELD % 48.7

AVERAGE SALES VALUE/LB. N/A

TABLE 1

PART D

OPERATIONAL DATA FACT SHEETS



KILOWATT DEMAND LOAD PROFILE

INDUCTION FURNACE & GENERAL PLANT SERVICE

FOUNDRY I

FIGURE 1

OPERATIONAL DATA FACT SHEET

CORELESS INDUCTION FURNACE

(NO DATA AVAILABLE)

Furnace make____________________ Transformer KVA____________________

Model____________________ Primary Voltage____________________

Capacity____________________ Secondary Voltage____________________

Output____________________tons/yr.

____________________tons/day

Alloy____________________

Melt cycle____________________minutes

Tap Quantity____________________lbs.

Change Quantity____________________lbs.

Tap temperature____________________^oF

Holding temperature____________________^oF

Slag cycle____________________minutes

Fume collection____________________CFM

Water cooling....GPM, Temp.........in ^oF.......Out ^oF

Type of Refractory____________________

Energy consumption____________________KWH/YR

Energy Cost____________________¢/KW

TABLE 1

OPERATIONAL DATA FACT SHEET

GAS MELT FURNACE DATA

Metal type: Aluminum + Brass

Annual tons 780

Pouring or tap temperature 2200 °F

Heat content Btu/lb

Shifts/day One

Melting period hrs. 8

Holding period hrs. 16

METHOD OF MELTING	CRUCIBLE	REVERB
Metal melted/hr.lbs.	2,000	
Burner rating Btu/hr	1.5×10^6	
Total gas usage/hr	2,500	
Capacity of furnace lbs.	2,000	
Crucible diameter	36"	-
Area of metal radiation sq.ft.	4.0	
Area of refractory wall:		
Below metal	110	
Above metal	-	
Thickness of wall	6	
Door open area or dip well sq.ft.	-	-
Mean temperature of walls °F	-	-
Outer temperature of walls T_1	100°	
Inner temperature of walls T_2	3,000°F	
Present refractory K value	N/A	
Proposed refractory K value	-	-
Rs value for refractory	-	-
CO_2 flue gas reading	6% CO_2	
Combustion air cfm	N/A	
Combustion air wg	N/A	
Flue gas (or comb.) temperature	1,000°F	
Ambient temperature °F	-	-
Time of day used	-	-
Days/year used	240	
Energy cost/therm $	0.275	

TABLE 2

OPERATIONAL DATA FACT SHEET

LADLE PREHEAT DATA

LADLE CAP TONS	N/A	HEAT CYCLES/DAY	N/A
LADLE AREA INSIDE	N/A SQ FT.	LINING THICKNESS	N/A
COVERED	No	TYPE OF LINING	Conventional F.B
INSIDE TEMP	N/A ^{o}F	OUTER SHELL TEMP	N/A ^{o}F
AMBIENT TEMP	Varies ^{o}F		
GAS USAGE/HR	216 CU FT.	CO_2 READING	N/A
COMBUSTION AIR	N/A CFM	PRESSURE	N/A WG
PREHEAT CYCLE TIME	N/A HRS	FLUE TEMP	N/A ^{o}F
REFRACTORY K VALUE	N/A	RS VALUE	N/A
BLOWER HP	None	RECUPERATOR EFFCY	None
FUEL COST/THERM $	0.275	ANNUAL USE	912 BTU x 10^6
NUMBER OF UNITS IN USE	Two		

TABLE 3

PART "E"

ENERGY CONSERVATION POTENTIAL

PART E

ENERGY CONSERVATION POTENTIAL

METHODOLOGY

As discussed throughout this Study, certain input data is a prerequisite in calculating potential energy savings from different foundry processes. The lack of information pertaining to combustion air analysis and gas flow rates to various equipment precludes calculation of actual energy savings as illustrated in SECTION II of this Study.

Potential energy savings for upgrading gas-fired equipment will be figured on a percentage basis; percentages used are conservative as compared to documented savings, from similar changes, as recorded by the Foundry Industry.

Electrical energy savings are factual. Calculations are based on actual kilowatts consumed by melt furnaces. Load profiles were developed from utility company computerized data for 15 to 30 minute periods.

Electrical Energy Cost Savings

Electrical power cost savings can be realized by improved controls and changes in melting energy usage as calculated in the following worksheets.

Based on a sample billing period of one year, the cost reduction potential is;

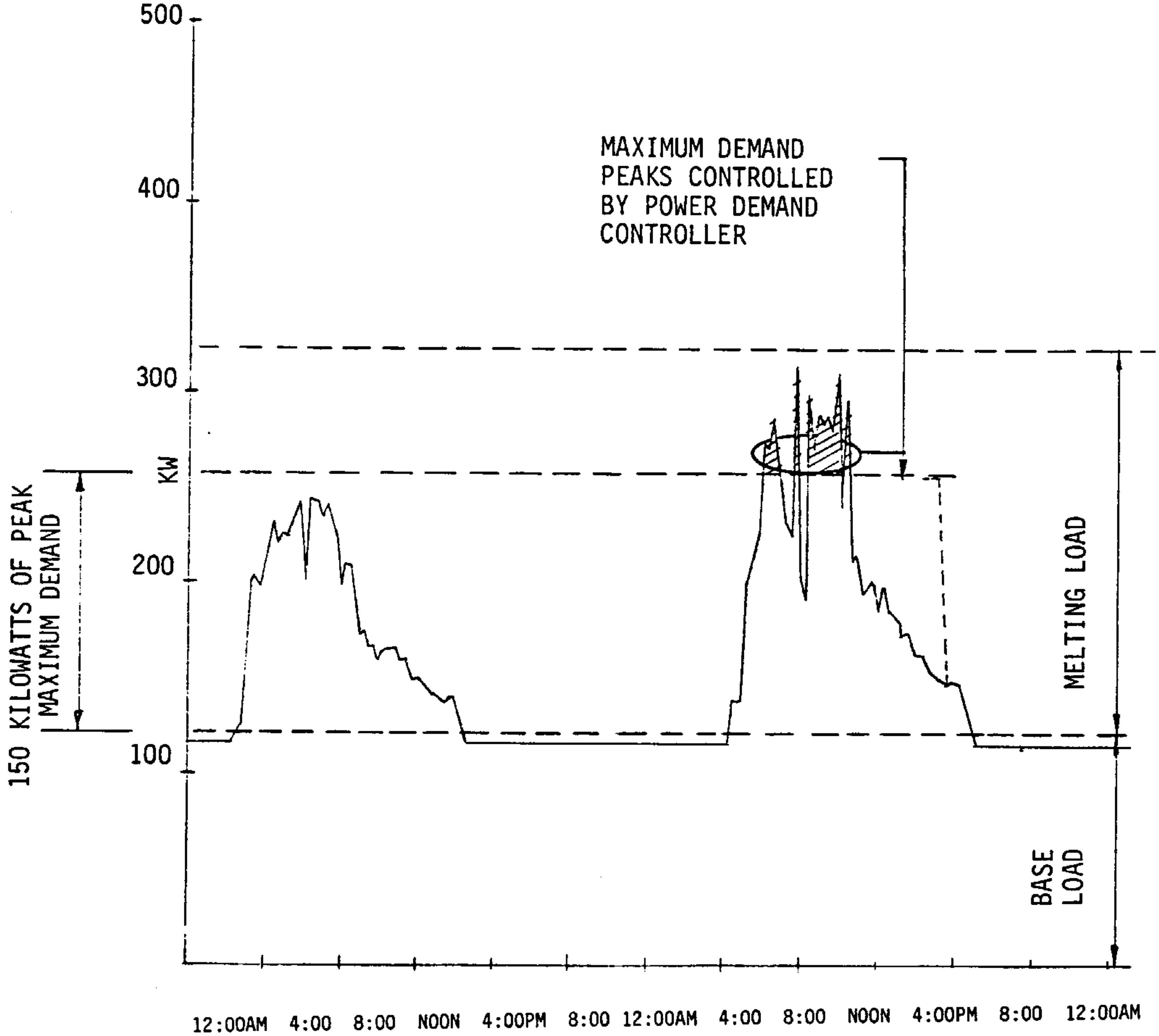
1. Demand Control

		Total
1/	Normal melting cost	9,622
	Demand limited cost	6,840
	Annual Savings	2,782

$$\text{Percent Savings} = \frac{\text{Reduction in cost}}{\text{Normal cost of melting}} = \frac{2{,}782}{9{,}622} = 29\%$$

For graphic illustration of methodology used in calculating electrical savings see Figure 1.

1/ Worksheet Table 1 and 2



KILOWATT DEMAND PROFILE
INDUSTRIAL ELECTRICAL RATE

FIGURE 1

DEMAND CONTROLLING

NORMAL MELTING COST			DEMAND CONTROLLING COST			
Month	Kilowatt Demand	Demand Charge	Kilowatt Demand	Demand Charge	Savings	%
Jan.	211	801.80	150	570	231.8	28.9
Feb.						
March						
April						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						
		9,621.6		6,840	2,781.6	

Potential yearly savings (average) = 29%
Based on a maximum demand of 150 kw.

TABLE 1

TOTAL MELTING ENERGY (Use actual metered consumption if available or estimate as follows:)

$$\frac{\text{Annual tons shipped}}{\text{Overall Foundry yield \%}} = \text{Total tons melted per year}$$

Total tons melted X average kWh/ton = Total energy

Example:

$$\frac{\text{Annual tons shipped}}{\text{Foundry yield \%}} = \frac{780}{.487} = 1{,}601$$

Therefore, Tons melted/year X kWh/ton* = 1,601 x 250

= 400,250 KWH

Percent melting energy of total electrical usage

$$\frac{\text{KWH}}{\text{Total Elect. Energy KWH}} = \frac{400{,}250}{605{,}761} = 66\%$$

*Note: kWh/ton determined from actual melt cycle or use industry average for type of furnace and metal melted.

TABLE 2

UPGRADING GAS FIRED FURNACES

The following table summarizes the probable cost and energy savings by carrying out all of the possible improvements previously covered in examples.

ITEM	EFFICIENCY PERCENT INCREASE
Combustion Efficiency	25.0%
Preheat Comb. Air	26.0%
Refractory Upgrade	6.4%
Furnace Covers	2.6%
TOTAL	31.8%

Overall Thermal Efficiency = 60.4%
Present Efficiency (Approximate) = 28.6%
Increased Efficiency = 60.4 - 28.6 = 31.8%

Annual cost savings based on percentage of natural gas used for melting is as follos:

average CFH 1/ = 3,700

Melting usage = 2,509

Percentage = 67.8%

Annual gas consumption 2/ = $12,219 \times 10^6$ BTU

Melting usage = $12,219 \times 10^6 \times 0.678$
$= 8,285.8 \times 10^6$ BTU/Year

@ 31.8 % improvement in efficiency 3/ from original level, the change in usage is equal to;

$$8285.8 \times 0.318 = 2,635 \times 10^6 \text{ Btu}$$

Annual cost reduction @ 0.275 per therm

$$= \frac{2,635 \times 10^6}{100,000} \times 0.275$$

= $ 7,246/year

1/ Ref. Table 4
2/ Ref. Table 2
3/ Ref. Section II (B-21)

PART "F"

ECONOMIC ANALYSIS

PART "F"

ECONOMIC ANALYSIS

Payback period is calculated as follows;

$$\frac{\text{Capital Investments}}{\text{Energy Cost Savings}} = \text{years}$$

In this facility, the electrical cost savings have been estimated based on similar savings shown to be attainable at other foundries. The cost of demand control equipment is in the order of \$ 4,000 with resulting payback of:

$$\frac{\text{Capital Investment}}{\text{Energy Cost Savings/yr.}} = \frac{\$\ 4{,}000}{\$\ 2{,}782} = 1.43 \text{ yrs.}$$

Gas fired furnace payback based on order of magnitude costs of approximately \$65,000 for the 5 units

$$= \frac{\$65{,}000}{7{,}246} = 8.9 \text{ years}$$

Ladle lining and burner improvements are not considered viable due to size and low gas usage.

PART "G"

SUMMARY OF ENERGY REDUCTION PROCEDURES

PART G

SUMMARY OF ENERGY REDUCTION

SUMMARY TABULATION

ITEM	ENERGY SAVED BTU x 10^6	COST SAVINGS	CAPITAL INVESTMENT	PAYBACK PERIOD
Demand Controllers	---	2,782	$ 4,000	1.43
Upgrading Crucible Melt Furnaces	2,635	7,246	65,000	8.9
TOTAL	2,635	$10,028	$69,000	6.8

Go To Main Menu

FOUNDRY "I"

PROJECTED ENERGY-EFFICEINCY RECORD

MONTH OR YEAR RECORDED				1979/80	
UNITS OF PRODUCTION				780	
FUEL COSTS					
• Electricity			$	40,111 2/	
• Natural Gas				22,183	
• Propane					
• Oil					
• Coke					
• Other					
		TOTAL	$	62,294	
ENERGY USED					
• KWH	605,761	x 3,412 Btu	=	2,066	Btu x 10^6
• Mcf Gas	9,584	x	1/	9,584	Btu x 10^6
• Gal. Propane		x 91,600 Btu	=		
• Gal. Oil		x 140,000 Btu	=		
• Coke - lb.		x 12,500 Btu	=		
•			=		
		TOTAL BTU		11,650	Btu x 10^6

ENERGY USED PER UNIT OF PRODUCTION

$$\frac{\text{(Million Btu)}\ 11,650}{\text{(Units)}\ 780} = 4.9 \text{ Btu} \times 10^6$$

COST PER MILLION BTU

$$\frac{\text{(Energy Cost)}\ 62,294}{\text{(Million Btu)}\ 11,650} = 5.34 \text{ Cost/Btu} \times 10^6$$

COST PER UNIT OF PRODUCTION

$$\frac{\text{(Total Cost)}\ 62,294}{\text{(Units)}\ 780} = 79.86 \text{ Cost/Unit}$$

1/ 1 Mcf = 1,000 cu.ft./hr - See Gas Bill for Btu content/cu.ft.

2/ 1980 projected electrical cost.

TABLE 1